

National Aeronautics and
Space Administration



NASA STRATEGIC PLAN 2018

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COVER IMAGE CAPTION AND CREDITS

Front Cover:

NASA incorporated the Administration's plans for space exploration in the design of the *2018 Strategic Plan* cover image. This vision embodies a shift in National space policy to a U.S.-led, integrated program with private sector partners for a human return to the Moon, followed by missions to Mars and beyond.

In addition, NASA's four strategic themes at the foundation of this plan are infused in the artistic compilation of the cover, as seen below. While not solely connected to, or limited to the subject they pertain to, these theme "images" reference ideas related to the Administration's and NASA's goals:

- *DISCOVER*
- *EXPLORE*
- *DEVELOP*
- *ENABLE*



Additional information regarding these four themes can be found on pages 6 and 7.

Back Cover:

The United States flag flies in the Cupola Observational Module, a 360-degree observation point inside the International Space Station. Image Credit: NASA <https://www.nasa.gov/image-feature/us-flag-in-the-cupola>

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LETTER FROM THE ACTING ADMINISTRATOR

February 12, 2018

I am pleased to present NASA's 2018 Strategic Plan, outlining the direction for the National Aeronautics and Space Administration (NASA) through 2021 and beyond. Our new strategic plan embraces the bold direction laid out for the Nation by President Trump in Space Policy Directive 1 and makes real the vision set forth by the National Space Council. The plan emphasizes achievement aligned to the three strategic themes of Discover, Explore, and Develop, as well as a fourth theme focused on the activities that will Enable our Mission. It provides the foundation for a U.S.-led return to the Moon for long-term exploration and use and to establish a foundation for eventual crewed missions to Mars and potentially beyond. It also reaffirms NASA's commitment to the advancement of science and aeronautics. The plan is intended to promote accountability and transparency for all of these efforts, while highlighting the tangible and intangible benefits these activities will return to the American people.

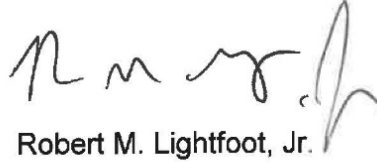


The plan features key milestones to be achieved by the Agency and highlights our close cooperation and support from commercial and international partners. Our robust partnership and commercialization strategy incorporates private sector innovation into NASA missions. Strategic partnering allows the Agency to better focus on new initiatives, improves the efficiency and effectiveness of our missions, and strengthens national science and engineering capabilities, boosting U.S. global competitiveness.

This plan emphasizes the importance of space exploration. NASA will maximize use of the International Space Station (ISS) to evaluate systems and options for safeguarding the health of astronaut crews, as we seek to deliver them safely to lunar and eventually Martian destinations and then bring them safely back to Earth. Targeted research onboard the station will focus on understanding how humans adapt to the space environment, developing the technologies needed for deep space missions, and enabling the economic development of low Earth orbit. We are looking to secure the Nation's long-term presence in low Earth orbit by partnering with industry to develop commercial orbital platforms and capabilities that the private sector and NASA can use after the cessation of direct U.S. Federal funding for ISS in 2025. NASA intends to shift its human spaceflight program out to the Moon and cis-lunar region, evaluating new habitat technologies, surface transportation systems, fuel generation, and storage solutions, as well as additional technologies that need to be developed prior to traveling to the surface of the Moon and deeper into space. In every domain, we intend to renew and strengthen our commitment to American commercial space companies, which are critical partners in the human exploration of the Moon, Mars, and beyond.

NASA will also build on its legacy of leadership in acquiring knowledge and understanding of the big questions in science, as well as the technologies of tomorrow. Through a steady cadence of focused, competitively sourced science missions, we will continue to lead the world in improving humanity's understanding of the Earth, the Sun, the planets in our solar system, and the secrets of the universe. Finally, NASA will continue to pioneer ground-breaking advances in aeronautics, where cutting-edge research including our partners in industry, academia, and other Government agencies will lead to improved air transportation safety and efficiencies. A lean and focused portfolio of fundamental and applied research allows engineers and scientists across the globe to seek and discover solutions for the safety and betterment of all.

NASA acknowledges and is grateful for the steadfast support it receives from the Administration, Congress, and the American people. This strategic plan reflects a national consensus as depicted in the Administration's policy and budget, the NASA Transition Authorization Act of 2017 and Congressional appropriations legislation, and the continued interest and excitement of the American people, who truly Enable NASA to Discover the scientific truth that governs our universe and beyond, to Explore new worlds, and to Develop unsurpassed science and engineering capabilities for the Nation.

A handwritten signature in black ink, appearing to read 'R M Lightfoot, Jr.', with a stylized flourish at the end.

Robert M. Lightfoot, Jr.
Acting Administrator

AGENCY INFORMATION

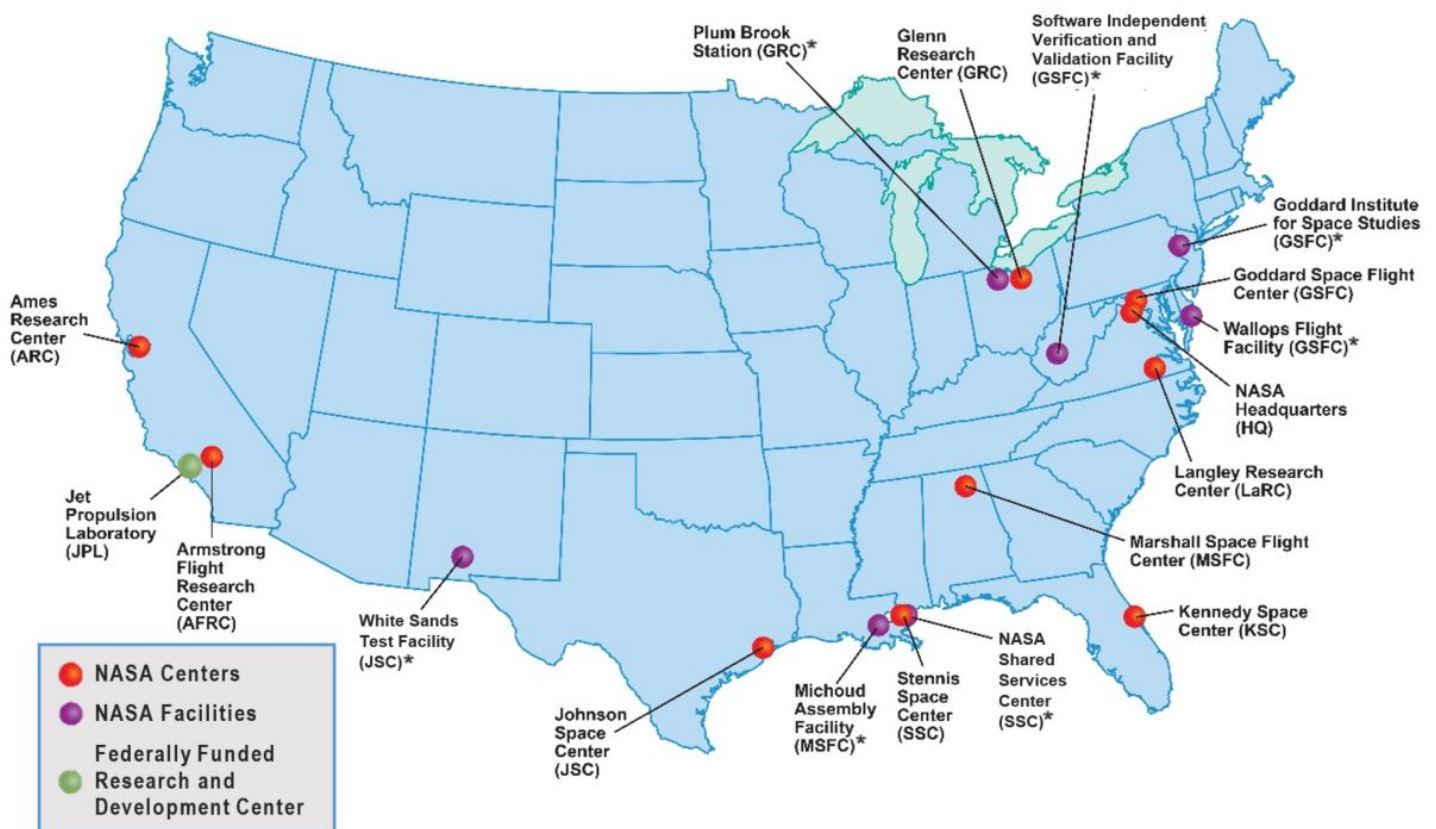
Welcome to NASA!

NASA produces a strategic plan every four years, in accordance with the new Administration, to outline our vision for the future and to provide a clear, unified, and long-term direction for all of NASA's activities. It is available in electronic form on NASA's website at <http://www.nasa.gov/news/budget/>.

Centers and Facilities Nationwide

The NASA workforce of approximately 17,400¹ civil servants is distributed among its Centers, facilities, and Headquarters, as shown in Figure 1. Each location is supported by a contractor workforce providing technical and business operations services.

NASA Centers and Facilities



*Acronym indicates the managing NASA Center for the Facility

Figure 1. NASA Centers and Facilities

¹ NASA Workforce Profile, Workforce Information Cubes for NASA (WICN). Last updated November 8, 2017. <https://wicn.nssc.nasa.gov>

NASA Organizational Structure

Headquarters organizations lead Agency budget development, execution, performance planning, and assessment functions. NASA's structure as of early 2018 was the following:

- The [Science Mission Directorate \(SMD\)](#) expands the frontiers of Earth science, heliophysics, planetary science, and astrophysics. Using robotic observatories, explorer craft, ground-based instruments, and a peer-reviewed portfolio of sponsored research, SMD seeks knowledge about our solar system, the farthest reaches of space and time, and our changing Earth.
- The [Aeronautics Research Mission Directorate \(ARMD\)](#) transforms aviation with research to dramatically reduce the environmental impact of flight, and improves aircraft and operations efficiency while maintaining safety in increasingly crowded skies. ARMD also generates innovative aviation concepts, tools, and technologies for development and maturation by the aviation community.
- The [Space Technology Mission Directorate \(STMD\)](#) pursues transformational technologies that have high potential for offsetting future mission risk, reducing cost, and advancing existing capabilities. STMD uses merit-based competition to conduct research and technology development, demonstration, and infusion of these technologies into NASA's missions and American industry. This mission directorate is being refocused as a new Exploration Research & Technology (ER&T) organization to support exploration as a primary customer.
- The [Human Exploration and Operations Mission Directorate \(HEOMD\)](#) leads human exploration in and beyond low Earth orbit by developing new transportation systems and performing scientific research to enable sustained and affordable human life outside of Earth. HEOMD also manages space communication and navigation services for the Agency and its international partners.
- The [Mission Support Directorate \(MSD\)](#) enables the Agency's missions by managing institutional services and capabilities. MSD is actively reducing institutional risk to NASA's current and future missions by improving processes, stimulating efficiency, and providing consistency and uniformity across institutional standards and practices.
- The [Administrator's Staff Offices](#) lead the Agency by providing guidance and direction that cuts across all of NASA's work. These offices represent the Administrator with respect to safety and mission assurance, managing the workforce and its diversity, overseeing the acquisition and use of information technology, conducting financial and procurement operations, as well as coordinating international partnerships, legislative affairs, and STEM activities.
- The [Office of Inspector General \(OIG\)](#) promotes economy, effectiveness, and efficiency within the Agency by conducting independent and objective audits, investigations, and evaluations of Agency programs and operations. The OIG safeguards taxpayer dollars and the integrity of the Agency by detecting and preventing fraud, waste, and abuse.

NASA is restructuring the Agency to align with the new focus on exploration. As a first major step, the former Space Technology Mission Directorate and advanced technology work in the Advanced Exploration Systems program will be merged into a new Exploration Research & Technology organization. Two further options for the next step in aligning NASA's organizational structure with the Agency's focus on exploration are currently under review:

- Option 1: Creating two new exploration-focused mission directorates and eliminating the current HEOMD and STMD structure.
 - Exploration Operations Mission Directorate, which will focus on the ISS, commercial low Earth orbit operations, and crosscutting support areas required to support exploration, such as communications, and rocket propulsion.
 - Exploration Systems and Technology Mission Directorate, which will focus on deep space mission elements and technology development needs for sustainable human exploration.
- Option 2: Creating a single “super” exploration-focused mission directorate by pulling together all the exploration-focused areas in the current HEOMD and STMD organizations.

NASA will choose one of these two options (or potentially a hybrid option) this spring and prepare for implementation with the FY 2019 budget, meaning October 1, 2018.

ACHIEVING OUR VISION AND MISSION

NASA inspires the world with our exploration of new frontiers, our discovery of new knowledge, and our development of new technology. Our work benefits Americans and all humanity. Since NASA's inception in 1958 to present day, the Agency's history is written with each unique scientific and technological achievement. We have landed people on the Moon, visited every planet in the solar system, touched the Sun, and solved some of the core mysteries of our home planet. Today, our Nation's economic prosperity, National security, and cultural identity depend on our leadership in aeronautics, space exploration, and science. NASA accepts the challenge to continue our legacy of achievement and greatly expand the benefits we provide to mankind. Our success will be determined largely by the planning and investments we undertake today. This commitment is what drives our Vision, Mission, and overarching approach that form the core of our *2018 Strategic Plan*.

Vision

TO DISCOVER AND EXPAND KNOWLEDGE FOR THE BENEFIT OF HUMANITY.

Mission

LEAD AN INNOVATIVE AND SUSTAINABLE PROGRAM OF EXPLORATION WITH COMMERCIAL AND INTERNATIONAL PARTNERS TO ENABLE HUMAN EXPANSION ACROSS THE SOLAR SYSTEM AND BRING NEW KNOWLEDGE AND OPPORTUNITIES BACK TO EARTH. SUPPORT GROWTH OF THE NATION'S ECONOMY IN SPACE AND AERONAUTICS, INCREASE UNDERSTANDING OF THE UNIVERSE AND OUR PLACE IN IT, WORK WITH INDUSTRY TO IMPROVE AMERICA'S AEROSPACE TECHNOLOGIES, AND ADVANCE AMERICAN LEADERSHIP.

Overarching Approach – Foundations of Our Strategic Plan

NASA's historic and enduring purpose is aligned to four major strategic themes, also seen in four "sections" of the plan's cover artwork, and the four color-coded bookmarks used throughout the document.

These correspond to our missions of scientific discovery of the Earth, of other worlds, and of the cosmos as a whole; missions of exploration in our solar system with humans and robotic probes that expand the frontiers of human experience; and missions of development that advance new technologies in aeronautics and space systems that allow American industry to create and expand a nascent space marketplace to serve the needs of space exploration, both here on Earth and in near-Earth environments. In addition, the Agency has a number of activities in support areas that enable our missions. These four themes are discussed in more detail below and are reflected in the four strategic goals that frame NASA's *2018 Strategic Plan*.

In addition, NASA has maintained its continuity of purpose over time by serving the American public and supporting a number of National priorities, characterized by six major elements.

- Fostering New Discoveries and Expanding Human Knowledge
- Global Engagement and Diplomacy
- Interactions with the Nation's Security and Industrial Base Posture
- Economic Development and Growth
- Addressing National Challenges
- Leadership and Inspiration

These elements are a synthesis of White House policy documents ([National Space Policy of the United States of America](#)), statements made by the National Space Council, Congressional mandates, and independent sources (National Academies' reports '[America's Future in Space](#)' and '[Pathways to Exploration: Rationales and Approaches for a U.S. Program of Human Space Exploration](#)'). These elements are reflected in the messaging embedded throughout our strategic plan.

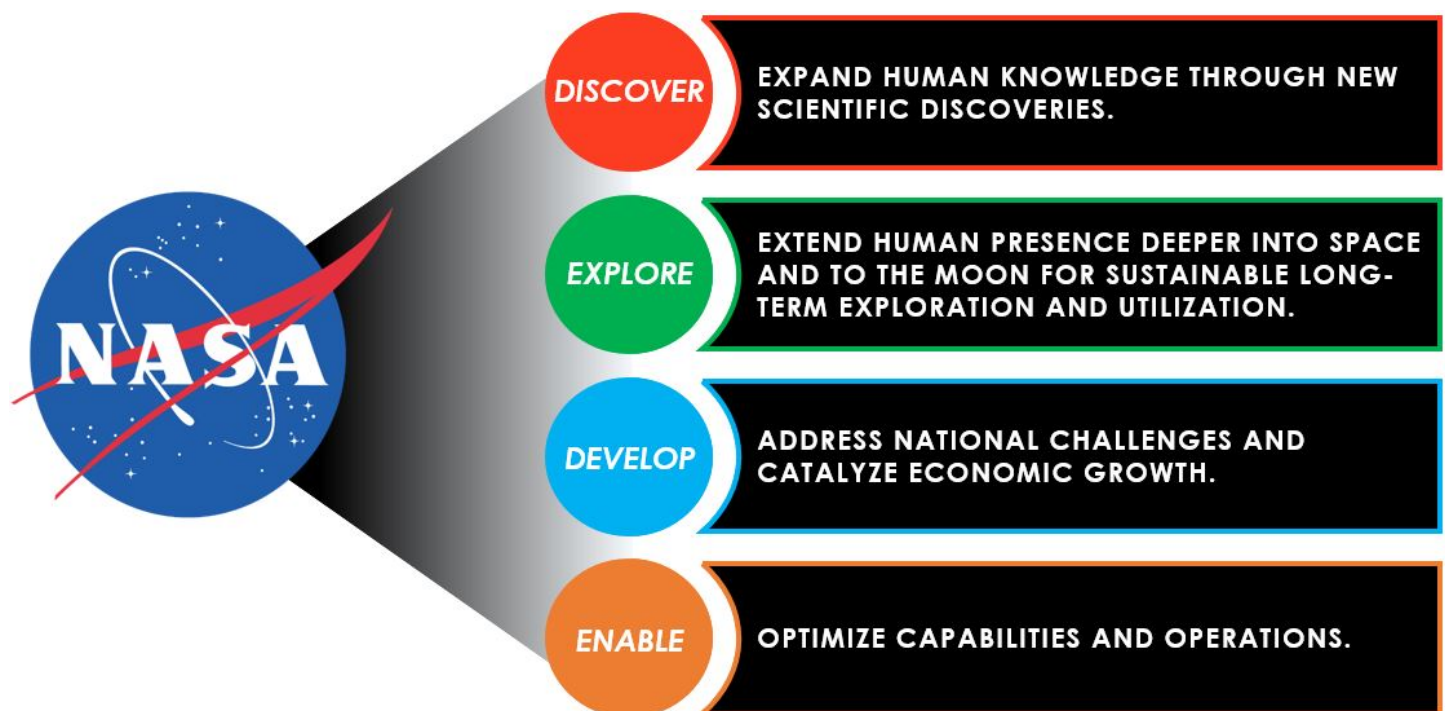
Our Strategic Plan and Priorities

We strive to accomplish our Vision and Mission with the utmost care—recognizing that we are stewards of taxpayer dollars, critical human capital, and one-of-a-kind facilities. With guidance from the White House, NASA will lead a new era of space exploration and advancements for our Nation. This plan outlines the strategic direction, goals, and priorities we will pursue to make this Vision of the future a reality. We have identified **four strategic goals** that will strengthen NASA's ability to accomplish its Mission and contribute to U.S. pre-eminence in space exploration, science, technology development, and aeronautics—all to the benefit of the American economy. Each strategic goal, as well as their corresponding strategic objectives, is outlined below and discussed in detail in the following section of this plan.

NASA's historic and enduring purpose is aligned to four major themes, characterized by a single word, that are reflected throughout the Agency's activities:

- **DISCOVER** references NASA's enduring purpose of scientific discovery
- **EXPLORE** references NASA's push to expand the boundaries of human presence in space
- **DEVELOP** references NASA's broad mandate to promote the technologies of tomorrow
- **ENABLE** references the capabilities, workforce, and facilities that allow NASA to achieve its Mission

In this plan, these four themes and their corresponding strategic goals are referenced using colored, numbered bookmarks in the top-right corner, and colored bookmark bars on the left of each strategic objective banner.



NASA 2018 Strategic Plan Framework

Theme	Strategic Goal	Strategic Objective
DISCOVER	EXPAND HUMAN KNOWLEDGE THROUGH NEW SCIENTIFIC DISCOVERIES.	<p>1.1: Understand the Sun, Earth, Solar System, and Universe.</p> <p>1.2: Understand Responses of Physical and Biological Systems to Spaceflight.</p>
EXPLORE	EXTEND HUMAN PRESENCE DEEPER INTO SPACE AND TO THE MOON FOR SUSTAINABLE LONG-TERM EXPLORATION AND UTILIZATION.	<p>2.1: Lay the Foundation for America to Maintain a Constant Human Presence in Low Earth Orbit Enabled by a Commercial Market.</p> <p>2.2: Conduct Exploration in Deep Space, Including to the Surface of the Moon.</p>
DEVELOP	ADDRESS NATIONAL CHALLENGES AND CATALYZE ECONOMIC GROWTH.	<p>3.1: Develop and Transfer Revolutionary Technologies to Enable Exploration Capabilities for NASA and the Nation.</p> <p>3.2: Transform Aviation Through Revolutionary Technology Research, Development, and Transfer.</p> <p>3.3: Inspire and Engage the Public in Aeronautics, Space, and Science.</p>
ENABLE	OPTIMIZE CAPABILITIES AND OPERATIONS.	<p>4.1: Engage in Partnership Strategies.</p> <p>4.2: Enable Space Access and Services.</p> <p>4.3: Assure Safety and Mission Success.</p> <p>4.4: Manage Human Capital.</p> <p>4.5: Ensure Enterprise Protection.</p> <p>4.6: Sustain Infrastructure Capabilities and Operations.</p>

DISCOVER

STRATEGIC GOAL 1: EXPAND HUMAN KNOWLEDGE THROUGH NEW SCIENTIFIC DISCOVERIES.

Goal Statement

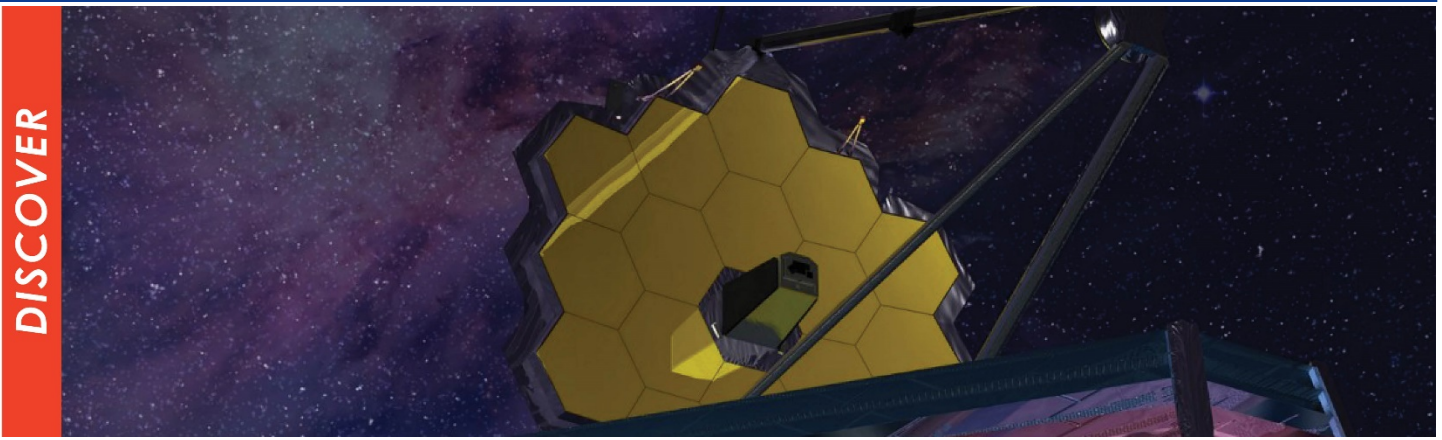
NASA's enduring purpose is scientific discovery and exploration for the benefit of the United States and humanity.

For almost 60 years, NASA's discoveries have been inspiring the world, rewriting textbooks, and transforming knowledge of humanity, the planet, the solar system, and the universe. NASA's missions have not only changed what we know, but also how we think as a society—truly civilization-scale science. NASA's missions and sponsored research provide access to the farthest reaches of space and time and deliver essential information about our home planet, directly improving life here on Earth.

Together, scientific discovery and human exploration improve and safeguard life on Earth. For example, Earth science research improves our weather forecasts and predictions of catastrophic events. Medical treatments have resulted from NASA studies on the effects of flight and low-gravity on the human body. Furthermore, NASA's technology developments contribute to economic stability and growth.

Scientific research is also opening the pathway for exploration and robotic-human partnerships. NASA's James Webb Space Telescope (Webb) is poised to be the premier observatory of the next decade—unlocking the mysteries of the universe for humankind. The International Space Station (ISS) is an orbital outpost for humanity. It is a blueprint for global cooperation and scientific advancement, a catalyst for growing new commercial marketplaces in space, and a test bed for demonstrating new technologies. It extends where humankind lives and is the springboard for NASA's next great leaps in human space exploration, including future missions to the Moon and beyond.

Finally, NASA acts as a champion of free and open access to scientific data. The Agency's work incorporates and builds upon the work of others in a spirit of global engagement and diplomacy. As more nations seek to use space for scientific investigation, the body of knowledge grows for the benefit of all.



The James Webb Space Telescope (Webb) will be the premier observatory of the next decade, serving thousands of astronomers worldwide. Image Credit: NASA/Artist Concept

Strategic Objective 1.1: Understand The Sun, Earth, Solar System, And Universe.

Conduct scientific studies of the Earth and Sun from space, return data and samples from other bodies in the solar system, peer out into the vast reaches of the universe, and play a catalyzing role in lunar robotic exploration by supporting innovative approaches to advancing science. These efforts are guided by National priorities and recommendations from the National Academies' decadal surveys and implemented through a balanced portfolio of programs.

Lead Office

Science Mission Directorate (SMD), with support from the Human Exploration and Operations Mission Directorate (HEOMD)

Objective Overview

The success criteria for SMD are progress in answering fundamental science questions, implementing the decadal survey priorities, and responding to direction from the Executive Branch and Congress. The most recent versions of the decadal surveys for SMD can be found at:

- [Planetary Science](#)
- [Solar and Space Physics](#)
- [Earth Science and Applications](#)
- [Astronomy and Astrophysics](#)

There are three core contexts of NASA's first strategic objective:

Discovering the Secrets of the Universe

NASA's science vision is to understand the Sun and its effects on the solar system, the Earth, other planets and solar system bodies, the interplanetary environment, the space between stars in our galaxy (the interstellar medium), and the universe beyond. NASA's journey of scientific discovery will help motivate, support, and prepare for human and robotic expansion throughout the solar system and beyond.

Searching for Life Elsewhere

"Are we alone?" is a central research question that involves biological research and research in the habitability of locations in the solar system such as Mars, the moons of outer planets, or thousands of potentially habitable worlds around other stars. This research supports a fundamental science topic at the interface of physics, chemistry, and biology.

Safeguarding and Improving Life on Earth

NASA investigates the hazards to life on Earth from the solar system, the Sun, and the Earth itself. This includes understanding the Earth as a system and on all time scales. NASA also works to detect asteroids and comets, understand their composition, predict their paths, and provide timely and accurate communications about potentially hazardous objects. NASA studies the causes and effects of severe space weather events to allow for preparation and timely response. Furthermore, NASA provides data and applications for operational use by first responders to natural disasters, firefighters, farmers, fishermen, transportation and commerce focused organizations, weather forecasters, and others.

Objective Strategy

NASA's strategy for understanding and solving the mysteries of outer space (including the Sun, Earth, solar system, and the universe) is complex. The following is a summary of NASA's direction and progress toward the aforementioned core contexts:

Discovering the Secrets of the Universe

NASA will pursue answers to important science questions to which the view from space makes a defining contribution. These science questions relate to agency priorities and guidance from National Academies' decadal research priorities. Answering these questions requires observations and measurements made from space, including direct measurements made from the surface of planets and objects in our solar system, and in some cases the analysis of returned samples in Earth-based laboratories.

NASA's success in science discovery across all three core contexts is based on a balanced program that involves a number of critical and enabling elements: laying the scientific and technical foundation for space-based missions through Research and Development (R&D); inventing and using new space-based observing and sampling capabilities; creating the context and capabilities to interpret the resulting data; and maximizing the return on investment in the acquisition of data. SMD's suborbital and ground-based programs are conducted to enable or complement space-based observations and train future mission scientists and engineers.

To complete innovative space missions NASA will effectively manage a diverse portfolio while balancing innovation with successful program execution. Specifically, NASA will:

- Measure mission success against clearly written top-level measurement requirements
- Develop objective criteria to enable unequivocal measurement of success or failure in meeting each requirement
- Establish a budget for each new mission that funds the mission's complete life-cycle cost, based on detailed engineering studies and independent cost estimates
- Obtain tactical-level community advice on portfolio adjustments via the NASA Advisory Council, Science Committee, and the science advisory committees
- Implement effective partnerships—commercial, international, interagency, academic, and others—that leverage NASA resources and extend scientific results

NASA will extend partnerships domestically and internationally. Science is a broad National and international enterprise and SMD partners with over a dozen U.S. Federal agencies and more than 60 nations and international research organizations to leverage ideas, capabilities, and resources. Like the ISS, NASA's constellation of Sun, Earth, solar system, and distant universe spacecraft and observatories are models of international and interagency cooperation and serve to further common scientific interests.

NASA will implement missions only after focused development has matured required technologies. A balanced science program proactively identifies potential technologies required to meet future mission requirements, conduct trade studies, assess development risks, and invest in new technologies well in

advance of mission implementation. NASA is also expanding the use of lower-cost CubeSats and SmallSats to accomplish our science goals.

NASA's science is uniquely positioned among Federal agencies to transfer content and expertise to an informative environment to support learning across all age groups. Data is accessible through multiple channels, which allows NASA to benefit from partners actively engaged in learning communities and emerging citizen-based science.

NASA also faces challenges in carrying out this science plan. Challenges include: access to space; strategic program planning; mission cost estimation and management; maintaining measurement continuity; and balancing near-term mission and research needs against increasing longer-term technology requirements. SMD engages the science advisory committees annually to rate scientific progress. In addition, in 2005 Congress directed that the performance of each division in SMD shall be reviewed and assessed by the National Academy of Sciences at five-year intervals.

Searching for Life Elsewhere

The search for life in the solar system and beyond is guided by the ability to understand how life originated on Earth and by the quest to find habitable environments outside of Earth. To improve the knowledge of environmental requirements for habitability, NASA will develop tools for detecting life, develop tools for determining the relative habitability of present or ancient environments, and explore analog environments on Earth. This will facilitate target selection for further robotic, and ultimately human, exploration. Observations from SMD's astrophysics missions have made it clear that habitable planets exist around stars other than the Sun and that such planets are plentiful. Improving techniques and ideas for discovering and characterizing habitable and/or inhabited environments on these planets, coupled with an understanding of the potential false positives for habitability or life, will enable prioritization of exoplanets for targeted follow-up observations. This will help to push frontiers in the coming decades of discovery and enable the search for signs of life on worlds that may be capable of harboring life, both within our own solar system and within the galaxy.

NASA's strategy relies on applying the lessons learned about the origin, evolution, and distribution of life on Earth to other bodies in our solar system and beyond. There is no single measurement or experiment that will definitively reveal the presence of extant or past life on a body in our solar system or a planet around another star. NASA will utilize many measurement results in a "Ladder of Life Detection" that will inform any certainty of the discovery of past or present life elsewhere.

Safeguarding and Improving Life on Earth

NASA's Earth science activities utilize observations from space to advance our scientific understanding of the Earth in service to the United States and the world. As we pursue answers to fundamental science questions about the Earth system on all time scales, we realize they benefit humanity in many ways. NASA's ability to view the Earth from the unique vantage point of space provides a broad and integrated set of uniformly high-quality data covering all parts of the planet. NASA shares this unique knowledge and data continuity with the global community, including members of the science, Government, industry, education, and policy-maker communities. For example, NASA's Earth science observations have proven helpful with crop area estimates, productivity assessments and yield models across a range of time scales, water planning and irrigation management, fisheries, and many more disciplines and industries. NASA measurements help American farmers, ranchers, agribusinesses, and local, state, and Federal agencies to improve the ability to produce food. NASA's Earth science data helps to advance U.S. National interests in agriculture by providing food security for the Nation, economic growth, products to trade internationally, and jobs here at home. Through our partnerships with other agencies that maintain forecast and decision support systems, such as the National Oceanic and Atmospheric Administration (NOAA), United States Geological Survey, and Environmental Protection Agency, NASA improves National capabilities to predict climate, weather, and natural hazards, to manage resources, and to develop environmental policy.

NASA's Near-Earth Objects Observations Program funds research activities to better understand the motions, compositions, and nature of near-Earth objects. This includes using optical and radar techniques to better understand objects' orbits, shapes, sizes, and rotation states. These planetary defense activities enable the science community to understand the nature of near-objects, information that could be leveraged to mitigate a possible Earth impact.

Space weather directly affects the safety of humans in space and on Earth by influencing the operation of electrical power grids, communications and navigation systems, gas and oil pipelines, and spacecraft electronics and orbital dynamics. NASA develops instrumentation, technology, models and research tools to understand space weather. NASA collaborates with agencies such as the National Science Foundation and NOAA to improve space weather predictive capabilities.

Contributing Programs (or Projects)

Cosmic Origins, James Webb Space Telescope, Exoplanet Exploration, Physics of the Cosmos, Mars Exploration, Outer Planets, Astrophysics Research, Astrophysics Explorer, New Frontiers, Discovery, Planetary Defense, Planetary Research, Heliophysics Explorer, Heliophysics Research, Living With a Star, Solar Terrestrial Probes, Earth Systematic Missions, Earth System Science Pathfinder, Earth Science Research, Earth Science Multi-Mission Operations, Applied Sciences, Earth Science Technology, Planetary Technology, and Suborbital Research [budget reported as part of other programs]



NASA astronaut Mark Vande Hei exits the International Space Station for a spacewalk in this photograph taken by fellow spacewalker Randy Bresnik on October 10, 2017. Image Credit: NASA

Strategic Objective 1.2: Understand Responses of Physical and Biological Systems to Spaceflight.

Conduct a robust program of space-based research to advance technologies that enable space exploration, and to pioneer uses of the space environment to benefit life on Earth.

Lead Office

Human Exploration and Operations Mission Directorate (HEOMD)

Objective Overview

The space flight environment stresses physical and biological systems in many ways, including microgravity and space radiation. Understanding the responses of physical and biological systems to these stressors is necessary for designing and executing longer, more distant human space flight missions. Living and working in space requires learning how living systems, from microbes and plants to complex organisms like humans, are influenced by the space environment. The same holds true for physical systems and processes such as fluid flow and combustion. These stressors can also be used as experimental tools to enable scientific discovery with applications here on Earth.

The ISS, conceived and constructed to be a laboratory in space, provides opportunities to understand the role of gravity in biological and physical systems. This strategic objective reflects NASA's commitment to make full and effective use of the ISS through the end of its current phase of operations, to close key gaps in the knowledge needed to build future exploration systems, and to realize the value of the space environment as a tool for science and technology. Guidance for research includes several studies by the National Academies over the past two decades:

- [Recapturing a Future for Space Exploration: Life and Physical Sciences Research for a New Era](#) (2011)
- [Review of NASA Plans for the International Space Station](#) (2006)
- [Assessment of Directions in Microgravity and Physical Sciences Research at NASA](#) (2003)
- [Microgravity Research in Support of Technologies for the Human Exploration and Development of Space and Planetary Bodies](#) (2000)
- [A Strategy for Research in Space Biology and Medicine in the New Century](#) (1998)

Objective Strategy

Exploration research is driven by well-defined NASA needs to enable long-duration crewed missions beyond low Earth orbit, while scientific discovery based research is driven by opportunities identified by external

organizations. In general, this research will be openly competed and peer reviewed; the participation of the research community external to NASA will be key. Areas to be explored for scientific discovery will be those that address pressing research questions in other Government agencies, private foundations, or commercial companies. The National Academies of Science, Engineering, and Medicine, which tap the advice of experts in science and engineering, will be a major source of community input for enabling exploration and pioneering scientific discovery.

Collaborations with external organizations will often be initiated and coordinated by the management entity for the ISS National Laboratory, the Center for the Advancement of Science in Space (CASIS), but will also result from direct agency-to-agency planning. The ultimate aim of these efforts is to make space-based research a standard component of the portfolio of traditional Federal and private R&D agencies, to the extent that other agencies are willing to take responsibility for the support of space-based capabilities.

The major risks to enabling exploration through understanding the responses of biological and physical systems to space flight are continuity of exploration architecture and funding. The major risk to addressing the pressing research questions of other organizations is the ability to conduct the research within a reasonable amount of time.

The first stages of progress toward achieving this strategic objective will be clearly measured by the formulation of agreements between the research programs on the one hand and the internal NASA customer (for enabling exploration) or external organizations (for scientific discovery) on the other. Such agreements will specify what research questions will be addressed by the NASA research programs and may include schedules. Subsequent progress will be measured by the accomplishment of intermediate milestones in the research program. Final accomplishment of the research objectives will be measured by showing how the research products address the original agreement's needs.

Contributing Programs (or Projects)

International Space Station Research



STRATEGIC GOAL 2: EXTEND HUMAN PRESENCE DEEPER INTO SPACE AND TO THE MOON FOR SUSTAINABLE LONG-TERM EXPLORATION AND UTILIZATION.

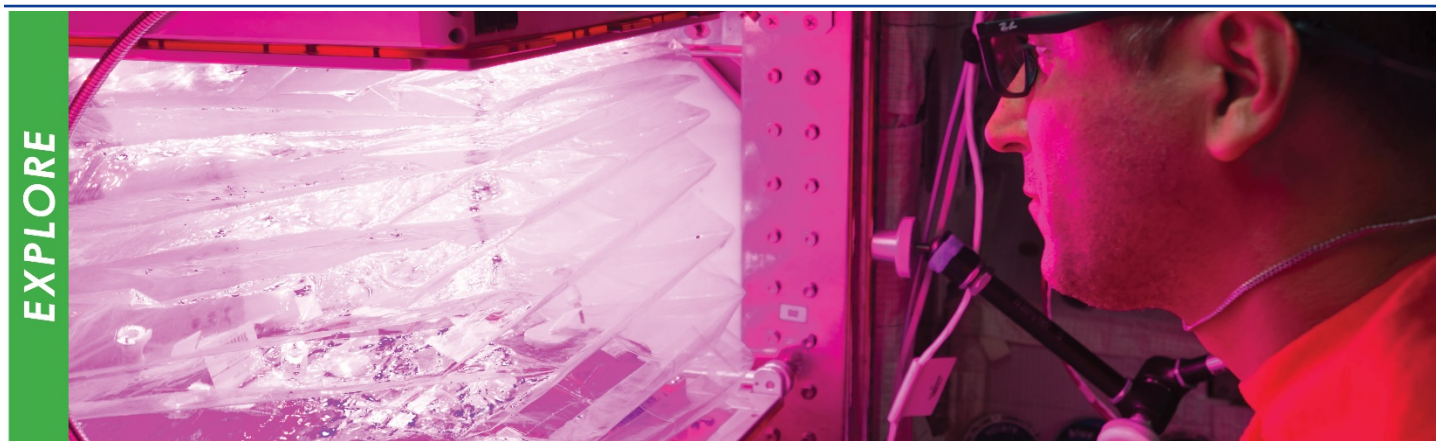
Goal Statement

America is a Nation of explorers. In everything we do—science, technology, commerce, the arts, sports— we strive to reach higher, farther, deeper, or faster than ever before in order to create a better future for the generations to come. NASA is pushing the same boundaries in space. Orbiting Earth aboard the International Space Station (ISS) right now, astronauts are preparing for space missions that will push the frontiers of human experience outward into the solar system. NASA is also laying the foundation for America to sustain a constant commercial, human presence in low Earth orbit.

From there, we will turn our attention back toward our celestial neighbors. We will return American astronauts to cis-lunar space and the Moon to build the foundation we need to send Americans to Mars and beyond. Cis-lunar space will be a stepping-stone, a training ground, a venue to strengthen our commercial and international partnerships as we refocus America's space program. NASA is testing technologies and techniques needed to keep humans safe, healthy, and productive on these future deep space missions. Ranging from environmental control and life support, to advanced propulsion and automated rendezvous and docking, these capabilities will be robust, affordable, sustainable, and adaptable to a variety of destinations.

NASA will pursue a sustainable cadence of compelling missions in preparation for the first crewed missions to deep space. These include the first test flight of the Space Launch System (SLS) and Orion crew vehicle near the Moon and the first crewed flight of this transportation system, designed for missions beyond low Earth orbit. At the same time, to support a broader strategy to explore and utilize the Moon and its surface, NASA is establishing a Lunar Orbital Platform - Gateway in cis-lunar space, to include a power and propulsion element by 2022, and habitation, airlock, and the required logistics capabilities soon after. In addition, to help pave the way for human exploration, NASA is planning to develop a series of robotic lunar missions to the surface of the Moon.

The United States will seek international partnership on a shared exploration agenda and spearhead the next phase of human space exploration. NASA will promote permanent human presence in space in a way that enables the 21st century space economy to thrive. It will take the best of NASA, the U.S. private sector, academic talent, and the capabilities of international partners to accomplish these bold missions.



NASA astronaut Joe Acaba prepared the Veggie Facility for three different kinds of lettuce seeds as part of the VEG-03-D investigation. Image Credit: NASA

Strategic Objective 2.1: Lay the Foundation for America to Maintain a Constant Human Presence in Low Earth Orbit Enabled by a Commercial Market.

Enable space-based low Earth orbit economy by transitioning ISS operations and maintenance to commercial and international partners, while continuing to leverage ISS for research, technology development, and to extend human presence in space.

Lead Office

Human Exploration and Operations Mission Directorate (HEOMD)

Objective Overview

NASA is using our resources to extend human presence in the solar system and to foster an emerging and robust commercial space market. The continuous operation of a research and technology demonstration platform in space is critical to achieving NASA's and the Nation's goals in science, technology, and human space flight.

The ISS is an experimental testing ground and is currently the world's only microgravity laboratory of its kind, enabling the discovery and development of advanced robotics, materials, communications, medicine, agriculture, and environmental science. Results of research projects on the ISS will continue to yield benefits in areas such as human health, telemedicine, physical science, Earth observations, space science, and education programs that inspire future scientists, engineers, and space explorers. The Center for the Advancement of Science in Space (CASIS) is the sole manager of the ISS National Laboratory and is working to maximize use of the ISS for research in space, which by law represents 50 percent of the resources of the U.S. portion of the ISS. Furthermore, human exploration activities on ISS will leverage the station as a test bed to demonstrate key exploration capabilities and operations and enable the move to deep space. Directly supporting the ISS until 2025 allows us to maximize its potential and maintain American leadership in space, while at the same time allowing us to foster the emerging U.S. low Earth orbit commercial space industry. After 2025, the U.S. will cease directly funding the ISS, but will continue to conduct research, technology development, and other activities in low Earth orbit in conjunction with our commercial and international partners. NASA will be a reliable customer for commercial goods and services that support and enhance NASA missions and requirements both in low Earth orbit and in deep space.

Critical to this objective is the selection, training, readiness, and health of crewmembers. All aspects of astronaut crew health are managed as part of this objective, including implementation of a comprehensive

health care program for astronauts, and the prevention and mitigation of negative long-term health consequences of space flight. Through these efforts NASA will maintain healthy, well-trained astronaut corps of sufficient size to meet all planned mission needs.

NASA's vision for low Earth orbit in the future is a self-sustaining space-based marketplace that provides economic benefits to the Nation and societal benefits to all people. The vision is one where NASA is one of many customers of privately-owned human-tended or permanently-crewed platforms and transportation capabilities that enable a variety of activities in low Earth orbit. Those platforms and capabilities will be sustained primarily by commercial revenue rather than relying on NASA and the U.S. Government for their main source of revenue. In this vision, NASA will maximize its resources toward missions beyond low Earth orbit, while still having the ability to utilize low Earth orbit for its ongoing needs.

Objective Strategy

NASA will continue to expand the use of the ISS on-orbit research program, including continuing to increase utilization of internal and external research facilities. Increasing facility occupancy is a function of the demand for the use of the ISS, which is driven by the funding of research by NASA, other Government agencies, and the private sector; and the capacity of the laboratory to support research, which is determined by the infrastructure in orbit, the transportation system, and crew availability. Beyond the current commercial crew and cargo transportation capabilities enabled by the ISS, NASA is continually exploring and implementing new partnership models to further enable commercial activities and markets in low Earth orbit.

Following an initial request for information and stakeholder workshops in 2014 and 2017, NASA developed a plan for achieving the vision for a sustained low Earth orbit economy, and is implementing activities and initiatives to make this vision a reality. To support low Earth orbit commercialization, NASA is leveraging the ISS by maximizing utilization and throughput, demonstrating the value of ISS and low Earth orbit research, utilizing more commercial acquisition strategies, and enabling greater commercial use of ISS by offering its unique capabilities and providing Earth-similar laboratory capabilities. Additionally, NASA is addressing the policy environment and associated elimination of barriers and introduction of incentives that could enable greater commercial use of low Earth orbit. Efforts to engage our international partners in promoting commercial activities are continuing through various ISS international partner forums.

NASA is also working to develop a healthy commercial supplier base for low Earth orbit activities. As discussed in [Strategic Objective 4.2](#), the ISS is already enabling commercial cargo and crew transportation that industry is working to become more cost effective in the future. Also, through initiatives such as Research, Engineering, Mission and Integration Services, NASA is transitioning from historically NASA-provided services for tasks such as payload integration, to purchasing those services from a wide variety of commercial suppliers whose capabilities have matured through expanded ISS utilization. NASA intends to continue to expand these types of commercial partnerships.

NASA is working toward the development of commercial markets and demand for low Earth orbit activities beyond the more “traditional” microgravity research and applications into broad sectors of the economy. Unless this demand is expanded, future private low Earth orbit platforms will likely not be viable without significant ongoing Government support. NASA and CASIS have identified several initial potential high payoff market areas and have increased the focus and resources toward projects in these areas, including protein crystallization, organ bioengineering, and in-orbit production/manufacturing.

To realize NASA's vision of a self-sustaining market in low Earth orbit, NASA has created the Commercial LEO Development Program to directly support efforts to expand commercial activities in low Earth orbit, with a focus on enabling, developing, and deploying commercial platforms that can be used by NASA and other customers.

Contributing Programs (or Projects)

International Space Station Systems Operations and Maintenance, Human Space Flight Operations



From a record breaking 18,300 applicants, NASA selected 12 new astronaut candidates to train for a variety of missions, including deep space missions on NASA's new Orion spacecraft and SLS rocket. Image Credit: NASA/Rob Markowitz

Strategic Objective 2.2: Conduct Human Exploration in Deep Space, Including to the Surface of the Moon.

Extend human presence into cis-lunar space and the lunar surface, with capabilities that allow for sustained operations in deep space and the lunar surface.

Lead Office

Human Exploration and Operations Mission Directorate (HEOMD)

Objective Overview

Over the next decades, NASA intends to extend U.S. leadership and to eliminate barriers of human exploration of space, and to do so in a way that enhances U.S. economic competitiveness. NASA is taking a phased approach to expanding human exploration, starting with exploration science and technology research aboard the ISS, extending to crewed missions around and eventually to the surface of the Moon, and eventually to the vicinity and surface of Mars. To support this approach, NASA is developing the capability to transport humans to and from deep space, enabling the exploration of our solar system using innovative, advanced technologies and partnerships. NASA is currently developing unique new systems for transporting people and cargo beyond low Earth orbit, including commercial cargo systems, the Orion crew capsule, the SLS heavy-lift launch vehicle, and supporting ground facilities. NASA is also defining other elements that would be needed to support missions on or around the Moon, and to Mars and beyond. Precursor robotic missions that investigate candidate destinations and provide vital information for human explorers will lay the groundwork for deep space exploration.

Sending astronauts into space involves a multitude of complicated systems, but perhaps the most complex system is the human system. The Human Research Program (HRP) is responsible for understanding and mitigating the highest risks to astronaut health and performance to ensure that crews remain healthy and productive during long-duration missions beyond low Earth orbit. HRP leverages the talents of researchers within NASA and across U.S. academia to implement a detailed plan for risk reduction, with much of this work taking place aboard the ISS. As NASA prepares to conduct crewed missions in cis-lunar space, on the Moon, and eventually at other locations including Mars, HRP biomedical research and technological development are enabling the Agency to safely send humans into deep space for longer durations.

NASA is increasing its capabilities for safely surviving in deep space for long durations to enable permanent, long-term human presence throughout the solar system. This deep space exploration can generate new knowledge and other new applications by scientists and entrepreneurs here on Earth.

Objective Strategy

NASA's development of new capabilities such as crew transport, heavy lift, and in-space habitation provide specific functions, which in combination with other capabilities, could advance human presence into our solar system. Rather than creating specialized, destination-specific hardware, these capabilities are designed to support multiple objectives in deep space and provide flexibility to carry out increasingly complex missions to a range of destinations over time.

The larger human exploration goal provides an overall strategic focus for a broad range of activities, with the ultimate purpose of extending human presence into the solar system, from low Earth orbit to cis-lunar space, Mars, and beyond. HEOMD strategy, development, and mission planning align and are guided by these key strategic principles for enabling sustained human exploration across multiple decades:

- **Fiscal Realism:** Implementable in the near-term with the buying power of current budgets
- **Scientific Exploration:** Exploration enables science and science enables exploration; leveraging scientific expertise for human exploration of the solar system
- **Technology Pull and Push:** Application of high technology readiness level technologies for near-term missions, while focusing sustained investments on technologies and capabilities to address the challenges of future missions
- **Gradual Build Up of Capability:** Near-term mission opportunities with a defined cadence of compelling and integrated human and robotic missions, providing for an incremental buildup of capabilities for more complex missions over time
- **Economic Opportunity:** Opportunities for U.S. commercial business to further enhance their experience and business base
- **Architecture Openness and Resilience:** Resilient architecture featuring multi-use, evolvable space infrastructure, minimizing unique developments, with each mission leaving something behind to support subsequent missions
- **Global Collaboration and Leadership:** Substantial new international and commercial partnerships, leveraging current ISS partnerships and building new cooperative ventures for exploration
- **Continuity of Human Spaceflight:** Uninterrupted expansion of human presence into the solar system by establishing a regular cadence of crewed missions to cis-lunar space during ISS lifetime

The ISS is a cornerstone of future deep space habitation and exploration activities, and its role is described in [Strategic Objective 2.1](#). The ISS and future low Earth orbit platforms provide outstanding opportunities to test and mature selected technologies and processes, such as environmental control, life support, communications, and navigation, power, and propulsion systems, which are required for exploration missions. Additionally, human research conducted on the ISS and future low Earth orbit platforms will help mitigate the health risks anticipated on exploration missions, such as visual impairment and intracranial pressure, pharmacology, nutrition, and muscle maintenance.

In the initial phase of operations around the Moon, early missions to lunar orbit will test and demonstrate flight and mission operations and staging of human-rated vehicles farther from Earth than ever before. Missions launched on commercial vehicles and the SLS in the 2020s will operate safely and productively in deep space. Lunar science missions may acquire samples or make measurements from the surface.

NASA will also continue to invest in exploration Research and Development (R&D) that will make future missions safer, more reliable, and more affordable. In parallel, NASA's science and technology organizations will continue developing research and technology to enable future human missions to the surface of Mars, and investigate approaches for reducing the costs of exploration missions to enable a more expansive and sustainable exploration program.

Contributing Programs (or Projects)

Orion, Exploration Ground Systems, Space Launch System, Human Research Program, Lunar Orbital Platform – Gateway, Advanced Cis-lunar and Surface Capabilities, Exploration Advanced Systems, International Space Station, Lunar Discovery and Exploration Program



DEVELOP

STRATEGIC GOAL 3: ADDRESS NATIONAL CHALLENGES AND CATALYZE ECONOMIC GROWTH.

Goal Statement

Originally tied to keeping the Nation secure and advancing U.S. leadership in aeronautics, communications satellites, and Earth remote sensing, NASA's mandate is broader today. The challenges NASA addresses relate to gathering climate change data; supplying technological solutions for terrestrial problems; advancing the state of Research and Development (R&D) in aeronautics and other fields; developing commercial and human space launch and transportation capabilities; understanding cosmic phenomena as wide-ranging as space weather, asteroids, and exoplanets; and improving the Nation's innovation capacity.

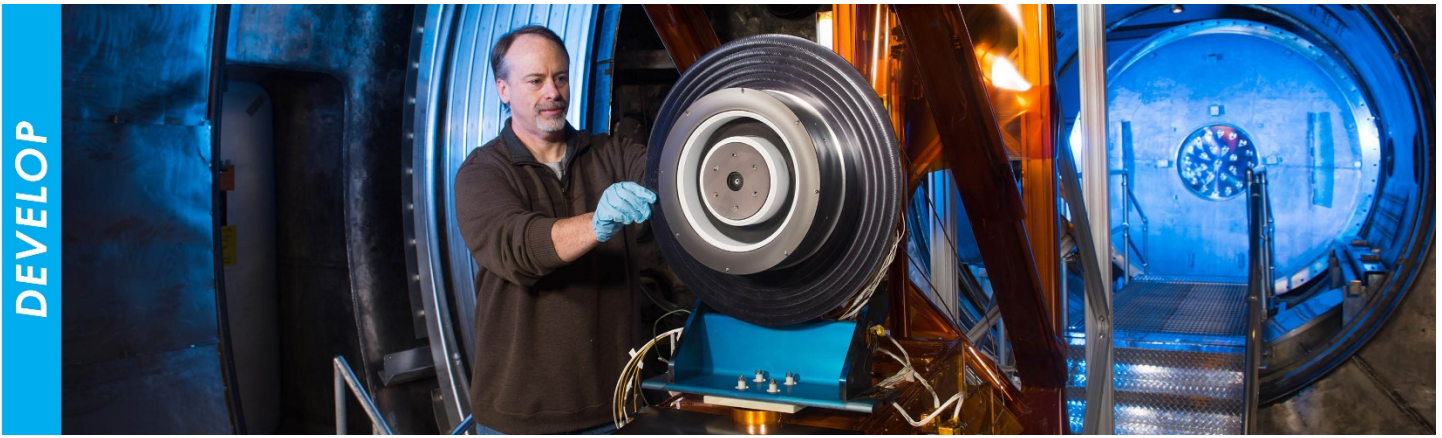
NASA drives economic development and growth; the National Aeronautics and Space Act of 1958 calls out this important theme, and the Agency generally invests more than 80 percent of its funds in U.S. industry and academia to carry out its missions of scientific discovery and exploration. In doing so, NASA engages and inspires young people to become scientists, technologists, engineers, and mathematicians. This ensures that the Nation's vast intellectual and industrial base—shared by many other Government agencies, including the departments of Defense, Commerce, Transportation, and Interior—has a continuous supply of bright minds and skilled hands. NASA enhances a core strategic advantage of the United States: the ability to attract partners and work with talent globally. Because of NASA's role in the international community, the Agency can help National security leaders manage global risks.

Technology drives NASA's future human and robotic exploration missions. As its technology efforts mature, NASA transfers appropriate technologies to industry and commercializes them to benefit a wide range of users. This ensures that the American people realize the full economic value and societal benefit of NASA's work. NASA also provides funding for fundamental technology research with broader benefit to the U.S. innovation system.

The aerospace sector is considered to be a rough gauge of a Nation's competitiveness, and the United States leads the world in this arena. NASA aeronautics research encompasses an ever-broadening array of technologies to make airplanes safer, quieter, and friendlier to the environment, and air travel more efficient. Today, NASA technology is found aboard every U.S. aircraft and inside every air traffic control facility in the country. This infusion can be attributed to one of the most productive public-private partnerships in U.S. history, as NASA continues to team with industry, academia, and other Government agencies.

Transformational demonstrations NASA plans in the next eight years will advance U.S. leadership for the next century of flight, and could bring about the return of overland supersonic flight; new airliners that consume half the fuel of today's models; safe, expanded use of unmanned aircraft systems, or drones, for economic and societal benefit; and safe, semi-autonomous small aircraft for personal "on-demand" transportation.

Attracting students to enter science, technology, engineering, and mathematics (STEM) fields is vitally important, and NASA's missions help to inspire the next generation. In 2015, public interest in NASA's mission to Pluto created an internet sensation, with more than 10 million views on the mission page, and 42 percent of all U.S. Government website traffic going to NASA during the historic flyby. NASA similarly inspired millions during Scott Kelly's year-long stay aboard the International Space Station (ISS), the first flight test of the Orion spacecraft for human exploration, the Mars rover landings, and many other significant missions. One of NASA's core missions is to ensure that our scientific and technological advances reach the widest possible audience to inspire the current and next generation of explorers.



NASA Glenn engineer Dr. Peter Peterson prepares a high-power solar electric propulsion thruster, a critical part of NASA's future deep space exploration plans. Image Credit: NASA, Bridget Caswell, Alcyon Technical Services

Strategic Objective 3.1: Develop and Transfer Revolutionary Technologies to Enable Exploration Capabilities for NASA and the Nation.

Advance revolutionary technologies for NASA and the Nation, involving commercial space products, specifically for utilization of near-Earth space; efficient transportation through space; access to planetary surfaces; enabling human space exploration; next generation science missions; and growth and utilization of the U.S. industrial and academic base.

Lead Office

Exploration Research & Technology (ER&T)

Objective Overview

Through the decades, NASA's technology development and transfer have enabled important space science and exploration missions, contributed to other U.S. Government agencies' needs, cultivated commercial aerospace enterprises, and helped foster a technology-based U.S. economy. [*Rising Above the Gathering Storm, Revisited*](#), a report by the National Academies, addresses the link between technology development efforts and the economy, noting that various studies indicate a strong link between economic growth and technological innovation in recent decades.

Over the next 10 years—through investments within the Exploration Research & Technology (ER&T) funding account—the Agency will advance revolutionary capabilities for both NASA mission challenges and National needs, and also address the market challenges associated with providing state-of-the-art commercial space products and services. More specifically, technology investments within the ER&T funding account will focus on the following thrusts.

- Accelerating large-scale industrialization of space
- Enabling efficient and safe transportation into and through space
- Increasing access to planetary surfaces
- Enabling humans to live and work in space and on planetary surfaces
- Expanding capabilities through robotic exploration and discovery
- Growing and utilizing the U.S. industrial and academic base

To support these strategic investment area thrusts, NASA will primarily invest in the following Exploration Campaign key focus areas: Advanced environmental control and life support systems & in-situ resource utilization; Power and propulsion technology; Advanced materials; Communications, navigation and avionics; Entry, descent, and landing; Autonomous operations; In-space manufacturing and on-orbit assembly; and Research to enable humans to safely and effectively operate in various space environments. In addition, ER&T contributes to growing the U.S. industrial and academic base to continue the Nation's economic leadership.

Objective Strategy

NASA pushes boundaries and rapidly develops, demonstrates, and infuses revolutionary, high-payoff technologies. The ER&T investment portfolios span a range of discipline areas and Technology Readiness Levels to advance technologies for the benefit of NASA, industry, and other Government agencies. This research and technology development engages universities, business, and all NASA Centers for widespread benefits. Through the ER&T account, NASA invests in transformational exploration technologies with high potential to offset risk, reduce cost, and advance critical capabilities for future NASA exploration missions and broader National needs.

Collaboration is key to NASA's strategy for achieving this objective. NASA collaborates with many other Government agencies on approximately 40 activities as of early 2018. These relationships allow NASA to utilize investments made by other agencies to meet NASA challenges, while contributing to other National needs. NASA also uses commercial partnerships with mutual benefit, addressing both NASA mission needs and the market challenges of providing state-of-the-art commercial space products and services. These investments in commercial space span the ER&T technology programs in addition to targeted activities through the NASA Technology Transfer Program and other partnerships. For example, NASA established public-private partnerships with the U.S. aerospace industry through the Tipping Point and Announcement of Collaborative Opportunity solicitations. NASA plans to continue such partnerships that leverage significant private sector capabilities and funds for the development of key technologies needed by both the Agency and the greater commercial sector.

NASA will evaluate progress toward this objective through transition and infusion of technologies in addition to varied assessments. The latter include annual strategic objective assessments; assessment of multi-year performance goals and annual performance indicators; annual Program Performance Reviews; Agency Baseline Performance Reviews; guidance from external committees and advisory groups; and external audits.

Key external risks to this objective include programmatic risk of access to space. To demonstrate new technology capabilities in space, NASA ER&T relies on rideshare and hosted payloads. Increasing costs and limited availability are also challenges. The latter is of particular concern, as NASA's technology demonstrations do not typically represent primary payloads for commercial launches.

Contributing Programs (or Projects)

Early Stage Innovation and Partnerships, Technology Maturation, Technology Demonstration, Human Research Program, Small Business Innovation Research, Small Business Technology Transfer



The design studies for the Low Boom Flight Demonstration X-plane (concept image above) are a first step toward supersonic overland flight and the possible return of quieter and more affordable supersonic passenger travel. Image Credit: NASA

Strategic Objective 3.2: Transform Aviation Through Revolutionary Technology Research, Development, and Transfer.

Maintain and advance U.S. global leadership in aviation through application of new concepts and technologies pioneered by NASA and developed in partnership with U.S. industry that lead to transformative improvements in mobility, efficiency, and safety.

Lead Office

Aeronautics Research Mission Directorate (ARMD)

Objective Overview

As a primary mechanism for physically connecting cities and countries across the world, air transportation is an integral part of today's U.S. and global economies. Aviation enables U.S. enterprises to operate on a global scale, providing safe and high-speed transport of people and goods. It accounts for more than \$1.6 trillion of U.S. economic activity each year and generates a positive trade balance—\$82.5 billion in 2015. The aviation industry also supports more than 11.8 million direct and indirect jobs in the United States, including more than one million high-quality manufacturing jobs. Aviation comprises more than five percent of the total U.S. gross domestic product. Nearly every product created and purchased today has been touched by aviation in some way. Globally, the aviation system is growing rapidly with the potential for more than five times as many passengers and 10 times the cargo in 2050 as today. Since its establishment, NASA has continually advanced America's aviation system to improve humanity's quality of life and productivity on Earth.²

NASA contributes unique innovations to aviation through research activities. These innovations serve as key enablers for the role of U.S. commercial aviation in sustaining American commerce and safe, environmentally sustainable mobility, and hence the Nation's economic well-being. NASA's role is to explore early stage concepts and ideas, develop new technologies and operational procedures through foundational research, and demonstrate the potential of promising new vehicles, operations, and safety technology in relevant environments. The Agency is focused on appropriate cutting-edge research and technologies to overcome a wide range of aeronautics technical challenges for the Nation's and the world's current and future air transportation systems.

²Reference 1 - "The Economic Impact of Civil Aviation on the U.S. Economy," June 2014, Federal Aviation Administration, https://www.faa.gov/air_traffic/publications/media/2014-economic-impact-report.pdf.

Reference 2 - "Vision 2050," February 2011, International Air Transportation Association, http://www.iata.org/pressroom/facts_figures/documents/vision-2050.pdf.

Objective Strategy

To continue NASA's leadership in aviation innovation and enable a revolutionary transformation of the aviation system, NASA is focused on six major research areas, or ARMD Thrusts³, for the long-term future of aviation. These research Thrusts utilize the full capability of NASA's in-house aeronautics expertise. Through high-risk, high-reward research and technology development, NASA seeks to enable:

- Safe and efficient growth in global operations
- Innovation in commercial supersonic aircraft
- Ultra-efficient commercial vehicles
- Transition to alternative propulsion and energy
- Real-time system-wide safety assurance
- Assured autonomy for aviation transformation

Each Thrust is designed to address an important area of research and technology development that will further U.S. leadership in the aviation industry and enhance global mobility. This research is performed with an emphasis on multi-disciplinary collaboration focused on the critical, integrated challenges aligned to the six research Thrusts—what NASA refers to as convergent research. Together, these research Thrusts combine to enable safe, sustainable growth in the overall global aviation system, while pioneering transformative capabilities that will create revolutionary opportunities.

NASA works with partners in other Government agencies, aligned with the principles, goals, and objectives of the National Aeronautics Research and Development Policy and its related National Aeronautics Research and Development Plan, to achieve its missions. NASA also partners with industry and academia to support innovative concepts and technologies, and with international counterparts to leverage complementary investments. In pursuit of this objective, NASA encounters and manages several challenges and opportunities, including:

Inherent Risk

NASA pursues challenging, cutting-edge technology advances and aeronautics research goals that are inherently high-risk. In accepting this risk, NASA gains valuable knowledge and advances the capabilities of the Agency, even when results fall short of expectations. By increasing its knowledge base and developing potential new solutions, NASA makes better-informed decisions regarding committing future research resources and pursuing promising high-return investments.

Domestic Partnership Influences

NASA's domestic aeronautics partnerships enable leveraging investments in support of mutual objectives and avoiding duplication of effort. They ensure NASA is moving forward on the right challenges and improve the transition of research results to users. Through continual coordination with our partners, NASA mitigates risks and challenges faced by partners which may negatively influence schedules and research outputs.

Growing System Demands

As demand for greater global mobility increases, so does the pressure for the current aviation system to accommodate demand, reduce environmental impacts, and improve safety. Because the rate of system change may be greater than that achievable through incremental change, NASA may need to reach for more transformational concepts.

Strategic Global Partnerships

Many emerging economies are rapidly developing infrastructure and embracing next generation technologies, and partners around the world have increasingly advanced technical capabilities which complement NASA's

³ ARMD Thrusts are mission directorate internal and reflect ARMD's priorities

own. By carefully fostering international partnerships in pre-competitive areas, NASA supports the safe and efficient growth in global aviation important to the United States. In turn, this improves the potential for leveraging partnership investments, reducing duplication, and acquiring knowledge for NASA's research programs and capabilities.

For each one of NASA's six research ARMD Thrusts, near-term (2015 to 2025), mid-term (2025 to 2035), and long-term (>2035) community outcomes are determined. Reviews are conducted several times a year, to evaluate progress toward all such community outcomes using criteria such as NASA performance, partnership performance, and stakeholder buy-in.

Contributing Programs (or Projects)

Transformative Aero Concepts, Integrated Aviation Systems, Airspace Operations and Safety, Advanced Air Vehicles



University students examine research equipment at NASA's Kennedy Space Center for the X-Hab Challenge (eXploration Systems and Habitation) to keep humans healthy and productive in deep space. Image Credit: NASA/Glenn Benson

Strategic Objective 3.3: Inspire and Engage the Public in Aeronautics, Space, and Science.

Inspire, engage, educate, and employ the next generation of explorers through NASA-unique Science, Technology, Engineering and Mathematics learning opportunities.

Lead Offices

Mission Support Directorate/Office of Communications (OCOM)

Objective Overview

NASA has a long history of engaging the public and students in its mission through educational and outreach activities and programs. NASA's endeavors in education and public outreach began early on, driven by the language in Section 203 (a) (3) of the Space Act, "to provide for the widest practicable and appropriate dissemination of information concerning its activities and the results thereof, and to enhance public understanding of, and participation in, the Nation's space program in accordance with the NASA Strategic Plan." NASA's education and outreach functions aim to inspire and engage the public and students, each playing a critical role in increasing public knowledge of NASA's work and fostering an understanding and appreciation of the value of STEM, and enhancing opportunities to teach and learn. By augmenting NASA's public engagement and communicating NASA's work and value, the Agency contributes to our Nation's science literacy. NASA is committed to inspiring an informed society; enabling the public to embrace and understand NASA's work and value, today and tomorrow; engaging the public in science, technology, discovery, and exploration; equipping our employees to serve as ambassadors to the public, and providing unique STEM opportunities for diverse stakeholders.

This strategic objective includes proactive efforts to diversify the STEM pipeline to NASA internships and employment. NASA works to ensure grant recipient institutions are in compliance with [civil rights/equal opportunity laws](#) in accordance with criteria from NASA Form 1206, Assurance of Civil Rights Compliance. [Equal opportunity compliance and technical assistance](#) can help to identify and report diversity and inclusion best practices among institutions receiving NASA funds that can, in turn, help increase the number of underrepresented and underserved groups in STEM fields available to apply for NASA opportunities.

Contributing Programs (or Projects)

Office of Communications, Office of the Chief Scientist, Office of Diversity and Equal Opportunity



STRATEGIC GOAL 4: OPTIMIZE CAPABILITIES AND OPERATIONS.

Goal Statement

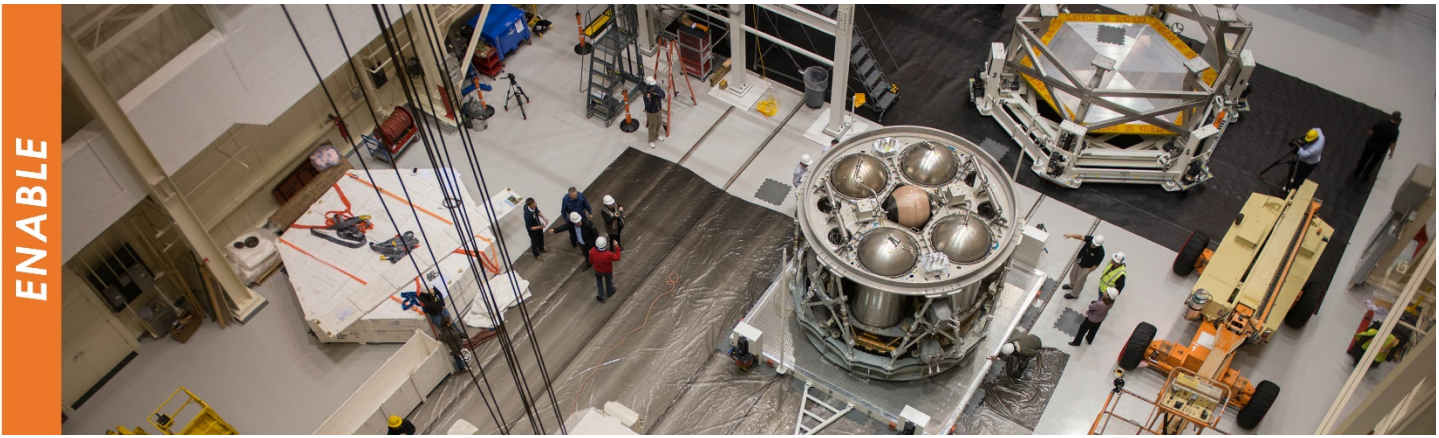
NASA is proud to be the U.S. agency charged with exploring the unknown in space and driving new advances in aerospace science and technology on behalf of the American public. Reaching for the stars requires dedicated, knowledgeable people and cutting-edge facilities and capabilities to provide the tools and support necessary to carry out our ambitious tasks. NASA strives to accomplish our mission with the utmost care — recognizing that we are stewards of taxpayer dollars, critical human capital, and one-of-a-kind facilities. NASA maintains a large and diverse set of technical capabilities and assets to support our missions, other Federal agencies' work, and the private sector to test, validate, and optimize innovations. The Agency understands that a skilled, valued, and diverse workforce is central to creating and maintaining the capabilities to explore the solar system and beyond and for understanding our home planet. NASA will continue to maintain and ensure the availability and safety of critical capabilities and facilities necessary for advancing our space-, air-, and Earth-based activities. This hybrid goal includes both strategic objectives and management focused objectives.

NASA has a renewed focus on its essential and distinctive technical capabilities. As a result, the Agency has adopted a new operating model that strengthens its management of the engineering and systems capabilities that are fundamental to every mission and strategic goal. This model provides for proactive, strategic management of these capabilities and allows NASA to optimize the allocation of technical specialties to its Centers, to select key areas for future investments, and to identify and transition those capabilities that are no longer needed or are better obtained from emerging National commercial sources.

Recognizing the growth of technologies and innovations increasing outside the Agency, NASA is instituting a robust partnership and acquisition strategy focused on leveraging and collaborating with the private sector and academia in order to benefit from their innovations. NASA's role in global engagement extends directly from the Space Act in areas such as data-sharing agreements and joint science and technology flight projects. More than two-thirds of NASA's science missions have foreign partners.

NASA's domestic and international collaborations are often pathfinders for other forms of cooperation, in part by demonstrating standards of best practices for civil and commercial space activities such as orbital debris mitigation, data sharing, openness, operational coordination, and flight safety. NASA plays a key role in setting global policies for aviation safety and access and specific standards and norms for space operations. NASA is most successful when it leads through example and practice, attracting partners who realize the benefits of shared values. Such principles include a shared understanding of the responsible use of space, free and open data policies, and the broad benefits of fundamental public Research and Development (R&D).

U.S. leadership in space is due in part to NASA's ability to inspire and create access to complex challenges. The Agency continues to retain and serve as a unique National resource of engineers, scientists, business and international specialists, and technologies. NASA provides the Nation with tools for leadership and inspiration in aerospace science and technology. This goal enables all of NASA's space-, air-, and Earth-based research and innovation activities, producing the best return on the Nation's investment.



The European Service Module, built by the European Space Agency, was tested at the NASA Glenn Research Center's Space Power Facility. It will supply Orion with electricity, propulsion, thermal control, air, and water. Image Credit: NASA

Strategic Objective 4.1: Engage in Partnership Strategies.

Support cooperative, reimbursable, and funded initiatives through domestic and international partnerships.

Lead Office

Mission Support Directorate (MSD)

Objective Overview

NASA identifies, establishes, and maintains a diverse set of domestic and international partnerships to enable collaborations of mutual benefit to NASA and other Government agencies, U.S. industry, academia, nonprofit organizations, state and local governments, and international entities that contribute to the Agency's strategic objectives and develop capabilities to achieve NASA's Mission.

NASA partners with other Federal departments and agencies, the U.S. private sector, non-profit organizations, universities, and foreign space agencies to coordinate, develop, and implement mutually beneficial cooperative space working groups, programs, projects, missions, and ground-based research activities that support NASA's *2018 Strategic Plan*. NASA also engages with Executive Branch offices on space policy and other interagency matters to ensure that the U.S. civil space program supports and enhances the broader policies and priorities of the U.S. Government and the Administration. These partnerships are instrumental in supporting the strategic goals and strategic objectives in NASA's *2018 Strategic Plan*. Such partnerships provide access to unique capabilities and expertise, increase mission flight opportunities, and enhance the scientific return of the Agency's missions.

Objective Strategy

NASA uses international and interagency partnerships to advance National priorities in global engagement and diplomacy, foster new discoveries and expand human knowledge, strengthen interactions with the Nation's security and industrial base, promote economic development and growth, address National challenges, and provide global leadership and inspiration. These partnerships strongly support NASA's Mission, U.S. foreign policy objectives, and Administration initiatives.

NASA has more than 1,200 domestic agreements with U.S. industry and other private sector entities in support of NASA's mission directorates and Centers. Such partnerships strengthen U.S. industry and are instrumental in supporting NASA's *2018 Strategic Plan*. For example, NASA is incorporating commercial space providers

into its core missions because these companies represent a source of capability the Agency needs and an opportunity to support a new area for U.S. economic growth and competitiveness.

Currently, NASA has over 800 active international agreements with more than 120 countries in a wide variety of programs, projects, and activities. While over half of these agreements are with the European Space Agency and partners in five countries (France, Germany, Japan, Canada and the United Kingdom), a large number are with partners around the world. The largest and most complex of all these partnerships is the International Space Station (ISS).

Currently, NASA has over 900 active interagency agreements with U.S. Government departments and agencies. NASA's scientific collaborations lend credibility and merit to projects, and expand the scientific prestige of the Nation. For example, NASA currently has partnerships with the National Science Foundation, the Department of Energy, and the Federal Emergency Management Agency.

NASA utilizes partnerships in support of the Agency's missions and programs of record. NASA implements its strategic plan to align resources to accomplish our goals in the most efficient and effective way possible. One such example includes encouraging a robust commercial space industry. NASA is leveraging its partnerships with the U.S. commercial space sector to lower launch costs and create more opportunities for commercial space flight. Another example is addressing critical problems such as air traffic capacity and the environmental effects of air traffic to safely enable the next generation of air transportation. NASA is working closely with the U.S. Federal Aviation Administration and other partners in several areas toward this end. Finally, exchanging mutually beneficial knowledge and information to spur innovation and incentivize the creation of new markets supports NASA's goals. The Agency also partners with U.S. industry to test experimental materials and share the resulting data.

Management tools ensure that NASA receives value and alignment from its partnership activities, including comprehensive training and guidance that are available on an on-going basis. Potential partnerships are evaluated at the Centers, by mission directorates, and by other key stakeholders in advance of establishing final agreements to ensure alignment with NASA's Mission. In addition, once completed, the Agency requires an assessment of partnerships that utilize NASA resources (activities performed on a "no exchange of funds" basis) to determine how beneficial the agreement was to furthering the Agency's objectives.

Key external factors for partnerships include: export control considerations; U.S. foreign policy; U.S. National security policy; U.S. National space policy; and changes in Government leadership or objectives in the U.S. and abroad.

Evidence and evaluation of progress in this area include: NASA internal and external reviews and audits; studies by the National Academies of Science, Engineering, and Medicine; audits by the Government Accountability Office; and other opportunities for assessment.

NASA's acquisition process, from strategy development through contract management and contract closeout, helps the agency achieve its various missions through development and implementation of domestic and international partnerships. The coordination and collaboration among these many strategic alliances creates integrated acquisitions that involve all interested parties early and throughout the process. From a management perspective, the objective is to avoid unnecessary expenses, delays, and disruptions.

Contributing Programs (or Projects)

Office of Procurement, Partnerships Office, Office of International and Interagency Relations, and Office of Small Business Programs

ENABLE



NASA's Commercial Crew Program is an innovative partnership with the American aerospace industry to develop space transportation systems to safely launch humans to low Earth orbit and the ISS. Image Credit: NASA

Strategic Objective 4.2: Enable Space Access and Services.

Support the communication, launch service, rocket propulsion testing, and strategic capabilities needs of NASA's programs.

Lead Office

Human Exploration and Operations Mission Directorate (HEOMD)

Objective Overview

NASA uses private and government capabilities to deliver people, payloads, and data to and from space. Two examples of such capabilities are the Commercial Crew Program (CCP) and the Launch Services Program (LSP). These programs implement strategic investment decisions to sustain and enable U.S. commercial industry and to provide transportation of crew, cargo, and key scientific payloads to their destinations in space.

The Space Communications and Navigation (SCaN) program manages and directs the ground-based facilities and services provided by the Deep Space Network (DSN), Near Earth Network, and Space Network. SCaN supports three reliable communications networks with data transmissions between space missions and Earth and provides navigation services to spacecraft in orbit. NASA's other technical capabilities in the Rocket Propulsion Testing (RPT) Program, Strategic Capabilities Assets Program (SCAP), and Space Environments Testing Management Office (SETMO) support commercial industries by providing specialized facilities to test and evaluate items to mitigate risk and optimize engineering designs. All of these capabilities are critical to enabling space missions that allow NASA and its partners to discover new science, explore the solar system, and develop transformative technologies and research that will drive the National economy.

Objective Strategy

Several programs manage the infrastructure and efforts that provide access to space for human exploration and robotic missions. Each of these programs and offices develop strategies to overcome challenges, manage risks, and contribute to the strategic objectives. These strategies complement NASA's overarching efforts to keep critical capabilities available that enable the mission success of NASA and other customers.

Some of NASA's key strategies for Strategic Objective 4.2 are to:

Provide access to space for the Nation's civil sector satellite and robotic planetary missions

The civil sector has multiple space-based missions. In addition to NASA's science and discovery missions, there are civil communications, geographic survey, and civil weather missions that provide key services for our Nation and the world. The National Space Transportation Policy identifies the NASA Administrator as the launch agent for the Nation's civil sector. LSP enables the Administrator to execute this role by acquiring and managing domestic commercial launch services for assigned missions; certifying new commercial launch vehicles for readiness to fly "high value" spacecraft; performing mission design and launch integration activities; and directing launch mission assurance efforts to ensure the greatest probability of launch mission success. While no space mission is "routine," whether going to low Earth orbit or some other Earth-centric orbit, what makes LSP a critical National capability is its unique launch system expertise involving payloads containing nuclear power sources, and for launching "one-of-a-kind" science exploration missions sent to other planets, the sun, or other locations in space. NASA relies on LSP to provide robust, reliable, commercial, and cost-effective launch services. NASA achieves assured access to space through a competitive "mixed fleet" approach utilizing the breadth of U.S. industry's capabilities. In addition, LSP provides launch related expertise to other NASA programs, such as Commercial Resupply Services and CCP, along with "launch advisory" support to NASA payload missions using launch services contributed by a foreign partner, to other government agencies, and to the launch industry as a whole.

Provide access to space for human exploration and cargo to and from the ISS and low Earth orbit from America

NASA's CCP facilitates the development of the U.S. commercial crew space transportation capability with the goal of achieving safe, reliable, and cost-effective access to and from low Earth orbit and the ISS. By supporting the development of human space flight capabilities, NASA is laying the foundation for future commercial transportation capabilities.

Commercial transportation to and from the ISS will provide expanded utility, additional research time, and broader opportunities of discovery on the orbiting laboratory. The station is critical for NASA to understand and overcome the challenges of long-duration space flight necessary for journeys to deep space. By encouraging industry to provide human transportation services to and from low Earth orbit, NASA can expand its focus on building spacecraft and rockets for deep space missions.

Ultimately, the goal is to establish safe, reliable, and cost-effective access to space. Once a transportation capability is certified to meet NASA requirements, the Agency will fly missions to meet its space station crew rotation and emergency return obligations.

Ensure responsive and reliable space communication and tracking services for NASA's missions

NASA's SCaN Network provides mission-critical communications services, and consists of a constellation of geosynchronous relay satellites, ground tracking stations for near-Earth and deep space missions, and their associated ground elements. The SCaN Network also enables missions from commercial space, other Government agencies, and collaborating international partners. SCaN provides these critical services by operating Government owned facilities, procuring commercial communication services, and utilizing capabilities of interoperable National and international partners. Recognizing the significant capabilities developed by the commercial communications satellite sector, SCaN is taking steps to reduce its reliance on Government systems and increase its usage of commercial services. Planned communications development of new technologies, such as optical communications, will enable new mission concepts, assist in maintaining safe operations for crew and vehicles, and bring the public along for the adventure as astronauts travel into deep space.

Manage capabilities effectively

NASA's RPT program is responsible for managing and sustaining the Agency's expertise and facilities for ground testing of rocket engines. It works both to advance new test technologies and to reduce propulsion test costs. The RPT program prioritizes its limited resources to sustain its core test capabilities and meet customer test requirements. In addition, the RPT program is NASA's representative on the interagency National Rocket Propulsion Test Alliance, which was established between NASA and the Department of Defense in 1998.

NASA's SETMO and SCAP manage functionally similar mission-critical capabilities ("capability portfolio")—a combination of workforce, competencies, assets, equipment, processes, and technologies—to meet NASA's needs. SETMO/SCAP capabilities include space environments testing, motion based simulation, and high-enthalpy materials testing (required for spacecraft that re-enter the Earth's and other planet's atmospheres). SETMO/SCAP's purpose is to sustain and ensure effective capabilities through centralized integrated management that includes a strategy aligned with requirements aggregated across multiple mission directorates, Centers, programs, and projects. The goals are to evaluate, prioritize, and optimize components within capability portfolios; identify and achieve needed Agency capability, capacity, and quality for the capability portfolios; allocate resources based on customer needs and requirements while maintaining alignment with Agency priorities; and continuously improve effectiveness and efficiency. SETMO/SCAP collaborates with other Government agencies, academia, and industry to ensure NASA's current and future missions have access to needed capabilities and assets that are owned and operated by NASA and outside organizations. In support of NASA's Mission, SETMO/SCAP provide the vision and leadership for these Nationally important capabilities (that include unique National facilities). By staying up-to-date on technological advances, industry demand, and issues that concern the public, NASA is able to make decisions on facility and capability investments and divestments.

Contributing Programs (or Projects)

Launch Services, Crew and Cargo, Commercial Crew, Rocket Propulsion Test, Space Communications and Navigation, Strategic Capabilities Asset Program (and Space Environments Testing Management Office)



Astronauts practice exit procedures from NASA's Orion spacecraft for their future journey and return to Earth from destinations beyond the Moon. Image Credit: NASA/Josh Valcarcel

Strategic Objective 4.3: Assure Safety and Mission Success.

Assure effective management of NASA programs and operations to complete the mission safely and successfully.

Lead Office

Technical Authorities: Office of the Chief Engineer (OCE); Office of the Chief Health and Medical Officer (OCHMO); and Office of Safety and Mission Assurance (OSMA)

Objective Overview

Safety and Mission Success (SMS) programs include programs that provide technical excellence, mission assurance, and technical authority. The elements of SMS reflect the recommendations outlined in many studies and by advisory boards and panels. These programs directly support NASA's core values and serve to improve the likelihood for NASA's programs, projects, and operations to achieve mission success while protecting the health and safety of NASA's workforce.

SMS programs protect the health and safety of the NASA workforce and improve the likelihood that NASA's programs, projects, and operations are completed safely and successfully. They contribute to the Agency's SMS by establishing applicable safety, engineering, and health policy directives and procedural requirements. Furthermore, SMS programs assure that directives and requirements are appropriately implemented, and perform independent technical analysis of safety and mission critical software products.

SMS programs develop policy and procedural requirements and provide assessments and recommendations to the Administrator, mission directorates, Center directors, and program managers who are ultimately responsible for the SMS of all NASA activities. SMS resources provide the foundation for NASA's system of checks and balances, enabling the effective application of the strategic management framework and the technical authorities defined in NASA's [Governance and Strategic Management Handbook](#). SMS programs enable risk-informed decision making by providing independent assessments of the technical challenges, independent technical analysis of safety and mission critical software products, and risks encountered by programs and projects. SMS practices verify that all pertinent policy and procedures have been followed or appropriate waivers have been obtained. The programs also participate in key decision point milestones and the Agency's Baseline Performance Reviews.

Objective Strategy

Discipline experts analyze the criticality of technical, safety, and health risks and evaluate risk acceptability through an established process of independent reviews, assessments, and technical analysis. The information and advice from these experts provide critical data and knowledge used by the Technical Authorities to develop authoritative decisions related to application of requirements within programs and projects.

Key indications to support SMS strategies for success include:

- The ability to independently assess the appropriate implementation of Agency safety, engineering, and health policies and procedures to a level of penetration required as determined by the risk assessed within programs and projects
- The ability to create and refine high fidelity safety, engineering, and health models to better enable risk informed decision making
- Continued implementation of the Agency's governance model that provides the independent Technical Authorities with direct access to Agency decision makers
- The ability to have reliability/risk data to inform hardware development, mission planning, and mission execution to assure Agency human space programs meet or exceed Agency safety threshold and goals for exploration missions during the next five to ten years
- The ability to independently verify and validate critical software safety and mission assurance capabilities

The annual Trilateral Summit (NASA, European Space Agency, and Japan Aerospace Exploration Agency) provides the opportunity for leading spacefaring nations to share best practices, lessons learned, and current concerns relative to completing missions safely and successfully.

SMS programs are charged with understanding and assuring that the Agency mitigates, to an acceptable level, all safety, health, and technical risks to NASA missions. NASA accomplishes this by evaluating hardware, software, environmental, and human performance aspects to identify hazards, including the impacts of new requirements and departures from existing requirements. Limited resources could impact NASA's ability to adequately implement an SMS program.

Contributing Programs (or Projects)

Program elements consist of work managed by the Office of Safety and Mission Assurance (OSMA), including the NASA Safety Center and the Independent Verification and Validation Program (IV&V); the Office of the Chief Engineer (OCE), including the NASA Engineering and Safety Center; and the Office of the Chief Health and Medical Officer (OCHMO)



Strategic Objective 4.4: Manage Human Capital.

Cultivate a diverse and innovative workforce with the right balance of skills and experience to provide an inclusive work environment in which employees that possess varying perspectives, education levels, life experiences, and backgrounds can work together and remain fully engaged in our mission.

Lead Office

Mission Support Directorate (MSD), Office of Human Capital Management (OHCM)

Objective Overview

Mission success is highly dependent on a skilled, technical workforce. Through this management objective, NASA will attract, select, develop, deploy and retain competitive talent. NASA will enhance the efficiency and effectiveness of human capital service delivery in order to operate more like a business, taking on leaner postures through identification of efficiencies.

As one of the leading employers of science, technology, engineering, and mathematics (STEM) professionals, NASA seeks to optimize the Agency's technical solutions through a workforce reflective of diverse ideas, life experiences, and backgrounds. Complementary to a diverse workforce is a work environment characterized by the key principles of equal opportunity: equity, fairness, and career advancement (e.g., access to growth opportunities and mentoring).

Objective Strategy

NASA will design and implement a new functionally-aligned architecture for human capital management with the goal of delivering consistent and effective human capital programs and services across NASA, while improving efficiency and reducing duplication. Progress will be initially assessed by maintaining or exceeding existing customer service standards. Long-term progress will be measured by resource savings.

In order for NASA to attract, select, develop, deploy, and retain competitive talent, within and external to the Government, NASA continues to implement state-of-the art and modern human capital programs including broad professional development for the workforce and leveraging opportunities to collaborate with other agencies on hiring flexibilities, especially for STEM skills.

Strategies relating to equal employment opportunity, diversity, and inclusion for the NASA workforce include, but are not limited to:

- Proactive efforts to ensure Equal Employment Opportunity and prevent discrimination in the workplace, such as the Agency's Anti-Harassment Program and the Reasonable Accommodations Program
- Regular assessment of the Federal Employee Viewpoint Survey's Inclusion Index
- Measurement of diversity increases through annual comparison with the U.S. relevant civilian labor workforce
- Targeted outreach and recruitment efforts to increase the diversity of the Agency's internship, fellowship, and early career hiring programs
- Greater access to career opportunity through mentoring and other forms of formal and informal education and awareness (networking and shadowing) for both managers and employees

External factors of relevance include the U.S. Census Bureau population projection, which indicates that by 2050 the current minority population will be 50 percent of the overall U.S. population.

Evidence and evaluation to assess program success are provided through the Agency's [Model Equal Employment Opportunity \(EEO\) Agency Plan](#), [Diversity and Inclusion Strategic Plan](#), and [Promising Practices for Diversity and EO](#) guidebook, which serve as the blueprint for its efforts in these areas.

Contributing Programs (or Projects)

Agency Management (Office of Human Capital Management and Office of Diversity and Equal Opportunity), Center Management and Operations

ENABLE



NASA astronaut, Reid Wiseman, Expedition 40 flight engineer, wearing a communication headset, uses a computer in the Columbus laboratory of the ISS. Image Credit: NASA/Reid Wiseman

Strategic Objective 4.5: Ensure Enterprise Protection.

Increase the resiliency of NASA's enterprise systems by assessing risks and implementing comprehensive, economical, and actionable solutions.

Lead Office

Principal Advisor for Enterprise Protection and Office of the Chief Information Officer (OCIO)

Objective Overview

Enterprise systems include NASA's mission programs and projects, information systems, and supporting institutional infrastructure. These systems are at risk of having disrupted, degraded, or denied environments due to natural, accidental, and malicious threats. This threat climate prompts the need for comprehensive risk assessments and risk-based safeguards for NASA's capabilities, technologies, and intellectual property. Insight, coordination, and action across the Agency will reduce the likelihood and consequences of enterprise protection risk.

NASA shares responsibility across its missions and mission support organizations to safeguard against these threats by operationalizing effective, innovative, and economical protections. The Agency's protection approach focuses on understanding, communicating, controlling, and, as appropriate, accepting these risks to the achievement of the Agency's objectives. This approach aligns with and supports the Agency's overarching enterprise risk management framework as well as Federal laws and policies for requirements such as cybersecurity. The Agency will balance its protections with appropriate openness and transparency to promote accessibility and citizen engagement in NASA's missions.

Objective Strategy

The Agency will coordinate safeguards to increase protection effectiveness, mature protection capabilities to reduce risks in NASA's complex ecosystem, and optimize protections in an economical manner. NASA will coordinate protection horizontally and vertically, across and within programs, projects, and institutions. NASA's technologies and systems must be trusted, resilient, and consistent with the Agency's requirements. This approach will require collaboration among the mission directorates, the Enterprise Protection Program, the OCIO, the Office of Protective Services, the Office of Strategic Infrastructure, the OCE, the OSMA, and NASA's Federal and commercial partners.

Enterprise-wide visibility is necessary to provide mission and mission support programs with optimal insight into the risks associated with threats. The Agency will conduct comprehensive vulnerability, susceptibility, and

mitigation assessments of existing and planned architectures, requirements, technology, systems, workforce, and other relevant factors. Analysis of these assessments will result in strategic, actionable recommendations to reduce protection risk. Coordination across the Agency will ensure that enterprise protection requirements, restrictions, and safeguards are addressed throughout the life cycle of NASA's programs, projects, and activities.

Cybersecurity threats can exploit the increasing complexity and connectedness of critical systems, placing NASA's missions and objectives at risk. The Agency must ensure the confidentiality, integrity, and availability of its data and IT assets to enable trust and resilience. NASA will increase the robustness of its cybersecurity capabilities to responsively identify and reduce vulnerabilities. This strategy depends on full adoption of the National Institute of Standards and Technology cybersecurity framework to enable NASA to identify, protect, detect, respond, and recover from cyberattacks. NASA is partnering with the Department of Homeland Security to modernize, and consolidate where appropriate, the Agency's IT infrastructure in alignment with the cybersecurity framework. NASA's personnel must be informed, trained, and vigilant to maximize the effectiveness of this comprehensive cybersecurity modernization.

As a steward of American taxpayer dollars, NASA must invest in affordable protection for its mission, corporate, and physical domains. Enterprise-wide visibility and coordination will strengthen NASA's ability to strategically and economically plan for and acquire safeguards. Data-driven operating model choices and acquisitions will reduce redundant contract vehicles, increase transparency, and drive down costs while optimizing protection effectiveness.

As threats evolve globally, NASA will evolve its ability to protect the Agency in alignment with Federal laws and policy related to enterprise protection. New mission and commercial capabilities will also introduce mission complexity and new risks. Success will depend on NASA's cooperation and partnerships with other U.S. agencies, academia, and the commercial sector for the exchange of knowledge, technologies, tools, and techniques for enterprise protection. NASA's missions and operations will be more resilient and accessible in a manner that protects the Agency's people, assets, and work. Coordinated policies, risk assessments, and actions coupled with mature, adaptive protection capabilities will underlie NASA's increased resilience and accessibility.

Contributing Programs (or Projects)

Enterprise Protection Program, Agency Information Technology Services, Agency Management (Office of Protective Services and Office of Strategic Infrastructure)



Looking up in High Bay 3 at NASA's Kennedy Space Center, the Vehicle Assembly Building completed the installation of 10 levels of large work platforms that will allow the stacking of the Space Launch System. Image Credit: NASA/Frank Michaux

Strategic Objective 4.6: Sustain Infrastructure Capabilities and Operations.

Enable NASA's Mission by providing the facilities, tools, and services required to efficiently manage, operate and sustain the infrastructure necessary to meet mission objectives.

Lead Office

Mission Support Directorate (MSD)

Objective Overview

Through this management objective, NASA is integrating and optimizing operations across Centers and Mission Support areas to reduce costs and revitalize the capabilities required to enable NASA's portfolio of missions. To address challenges associated with aging infrastructure, NASA is aggressively managing its facility portfolio to consolidate and modernize into fewer, more efficient, and sustainable facilities. Through a systematic assessment of service areas, NASA is consolidating and improving operations to balance risks across services and activities to provide a safe and reliable infrastructure.

Objective Strategy

NASA's mission support strategy is to steward resources by reducing costs, revitalizing capabilities, integrating capabilities across NASA Centers and Mission Support areas, and optimizing operations. To move toward a model of interdependence, NASA implements Business Services Assessment decisions. Our workforce depends on the availability of unique facilities, tools, capabilities, and services to successfully conduct our mission. Planning, operating, and sustaining this infrastructure and our essential services requires a number of critical institutional capabilities including management of finance, real property, and other support functions. To operate as efficiently as possible, NASA relies on its Shared Services Center to provide timely, accurate, and high quality business support services in a consolidated fashion to all NASA Centers.

Sustainable management of NASA's infrastructure ensures that our assets support our workforce in meeting mission requirements and schedules. NASA is increasing its inventory of sustainable buildings and awarding more energy savings performance contracts and utility energy service contracts, which enable energy service companies and utility companies to finance energy projects that NASA repays over time from avoided utility costs. In 2016, NASA added two Leadership in Energy & Environmental Design (LEED)-certified buildings to its portfolio, with a combined area of more than 21,000 gross square feet. It should be noted that a LEED-certified building from the previous year obtained a "2 Green Globes" certification from the Green Building Initiative last year. This 153,000 gross square feet building is the first NASA building to attain multiple

sustainable facility systems ratings. To support our mission, NASA has adopted a facilities maintenance and operation philosophy by proactively pursuing and adopting the safest, most cost-effective blend of reliability centered maintenance techniques, sustainability practices, and safety procedures. Other best practices conducted by NASA include providing safe, sustainable, efficient, and reliable facilities. Funding for reliability-centered maintenance and condition-based maintenance is set aside within the maintenance funding for Centers to invest in technology advancements, allowing Centers to better manage maintenance resources.

NASA is implementing the following recommendations and decisions from its Business Services Assessment that identified areas for improved management of the Agency's portfolio. A key recommendation is the development of an Agency Master Plan that identifies Agency facility priorities over a 20-year timeframe to assist the development of Center master plans in meeting Agency goals, missions, sustainment, and demolition activities. Another key decision is the appointment of a Facility Capability Leader to manage and implement the Agency Master Plan in the most effective and cost-efficient manner possible. Additional decisions include the implementation of improved processes to facilitate divestment, limitations for in-grant investments, and a revised methodology for prioritizing capital investments and repairs across the Agency. Improvements in operations and maintenance call for improving standards for levels of maintenance and more focused investment on condition-based maintenance and reliability-centered maintenance. This will maximize maintenance investments and optimize maintenance cycles for core critical assets.

NASA has instituted Capability Leadership as part of the Agency Operating Model. The model will advance and optimize deployment of resources and divestment of technical capabilities that are no longer needed. NASA is developing policies and processes for Capability Portfolio Management related to facilities and technical capabilities that will:

- Advise the Agency and ensure proper alignment across Missions and Centers
- Establish plans based on strategic needs to provide technical guidance to the Agency
- Determine gap areas for advancement and strategic investment
- Assess opportunities for investments and divestments
- Establish standards and specifications

Contributing Programs (or Projects)

Center Management and Operations, Agency Management (Office of Strategic Infrastructure)

FIELD CENTERS AND FEDERALLY-FUNDED RESEARCH AND DEVELOPMENT CENTER STRATEGIC GOAL CONTRIBUTIONS

Armstrong Flight Research Center (AFRC)

Strategic Goal 1 - Expand Human Knowledge through New Scientific Discoveries.

AFRC adapts and provides a preeminent suite of specialized aircraft and capabilities to observe the Earth's physical processes, test new observing technologies, and calibrate and validate Earth observing satellites worldwide. In this way, AFRC enables Earth science researchers to improve humankind's understanding of our planet and helps ensure the success of SMD's Earth Science mission—particularly its Airborne Science Program.

AFRC also maintains and operates NASA's Stratospheric Observatory for Infrared Astronomy (SOFIA), the world's largest airborne observatory. The Center leads SOFIA's hardware and software control systems; aircraft modifications, maintenance, and flight operations; and deployment planning and execution. It jointly leads the ground and flight safety for this unique capability.

Strategic Goal 2 - Extend Continuous Human Presence Deeper into Space and to the Moon for Sustainable Long-Term Exploration and Utilization.

AFRC directly engages in NASA's efforts to promote the commercialization of space. The Center supports commercial space providers, including the Sierra Nevada Corporation's Dream Chaser activity, which is part of NASA's effort to develop the commercial systems for low-cost access to low Earth orbit. It also develops aero-convergent solutions for low-cost access to low Earth orbit, such as the Towed Glider Air Launch System.

In addition, AFRC is involved in two other space-related efforts within NASA. For the Ascent Abort 2 mission, a crucial safety test for NASA's crewed Orion spacecraft, the Center provides the developmental flight instrumentation, and is organizing launch activities, which include scheduling facilities and purchasing the booster. AFRC also supports both the commercial space flight industry and the suborbital and small satellite orbital launch vehicle market.

Strategic Goal 3 - Address National Challenges and Catalyze Economic Growth.

AFRC has a rich history and enduring interest in aeronautics. The reinvigoration of NASA's Aeronautics mission has renewed interest in X-plane research. AFRC is a leader in this area, bringing years of experience and anticipating new ways to increase the efficiency of flight research. AFRC also leads NASA's efforts to provide Federal regulatory agencies the data they need to allow unmanned aviation systems, or drones, to fly regularly in the National air space. In addition, the Center enables emerging aviation markets by developing electric aircraft and methods to certify autonomous systems. AFRC looks to the new ER&T organization for opportunities to validate unique early stage technology. These efforts, while small, are extremely valuable to the Agency.

Strategic Goal 4 - Optimize Capabilities and Operations.

AFRC continuously analyzes the potential future requirements of the mission directorates, programs, and proposed future missions to optimize Agency capabilities through the Center's rigorous flight safety process. The technical workforce is key to innovation at AFRC. For this reason, the Center regularly assesses the workforce composition and rebalances as necessary.

Ames Research Center (ARC)

Strategic Goal 1 - Expand Human Knowledge through New Scientific Discoveries.

ARC conducts basic and applied research and technology development in aeronautics, astrobiology, astrophysics, and the planetary, biological, and Earth sciences. The Center is home to NASA's Mars Climate Modeling Center, the NASA Earth Exchange, and the virtual research organization known as the NASA Astrobiology Institute.

ARC also builds science instruments and payloads, with demonstrated expertise in infrared and ultraviolet/visible spectrometers, exoplanet imaging technologies, life detection technologies, airborne earth science instruments, and environmental life support systems.

ARC designed and operates the Kepler space telescope. It will process data for NASA's Transiting Exoplanet Survey Satellite. ARC also leads science operations for the SOFIA airborne telescope and guides design and development of low-cost lunar robotic lunar probes.

Strategic Goal 2 - Extend Continuous Human Presence Deeper into Space and to the Moon for Sustainable Long-Term Utilization.

ARC's work in life, lunar, and planetary sciences and entry system technologies is crucial to NASA's effort to send human explorers back to the Moon, on to Mars, and eventually throughout the solar system.

ARC leads the Agency's basic space-life research in cell and animal biology and its planning for robotic prospecting missions to gauge the quality and quantity of water and other resources that could sustain astronauts on the Moon. ARC also hosts NASA's solar system Exploration Research Virtual Institute, which engages scientists across America in studying the Moon and other potential destinations.

ARC operates unique and necessary facilities such as an arc jet complex to test heat shield materials and spacecraft structures in simulated hypervelocity flight conditions. This furthers development of probes that can visit planetary surfaces, collect rock and soil samples, and bring them back to Earth. It also helps ensure the safety of astronauts who will make their journeys in NASA's Orion crew vehicle.

Strategic Goal 3 - Address National Challenges and Catalyze Economic Growth.

Society and the economy benefit from ARC's experience developing autonomous and intelligent systems that can operate in complex and changing environments. One such place is the National airspace, where increasingly popular unmanned aviation systems, or drones, will be able to use collision avoidance systems and traffic management technology created at ARC to operate more safely and efficiently at low altitudes.

ARC connects NASA with partners in industry, academia, and Government to facilitate technology exchanges, both to increase the Agency's technical capabilities and to make NASA's technology portfolio available to its partners. One beneficiary is the Nation's growing private space sector, whose commercial crew and cargo transportation developers have access to specialized material technologies, flight-like ballistic range and arc jet testing, and numerical simulation.

Strategic Goal 4 - Optimize Capabilities and Operations.

ARC manages and operates several major and unique Federal research and testing facilities and serves as the nerve center for securing NASA's IT infrastructure. It hosts the Security Operations Center, which protects more than 100,000 devices and users across the Agency.

Research and test capabilities at ARC include the NASA Advanced Supercomputing Facility, which hosts one of the largest quantum computers; the Ballistic Range Complex, the Electric Arc Shock Tube, and the Agency's only arc jet complex, all for simulating hypervelocity flight conditions and high-fidelity human-in-the-loop

simulators that reproduce a range of conditions for aerospace systems and operations, human factors, and aviation safety.

There are two unique facilities for modeling nature's work on other planets. The Ames Vertical Gun Range helps characterize crater formation and the Planetary Aeolian Laboratory simulates the movement of windblown particles.

Glenn Research Center (GRC)

Strategic Goal 1 - Expand Human Knowledge through New Scientific Discoveries.

GRC provides radioisotope power and electric propulsion systems for science missions and uses expert knowledge in materials to develop and test electronics for extreme environments such as surface conditions on Venus. The Center is a global leader in the fields of microgravity combustion and fluid physics to understand the behavior of fire and fluids in space. GRC researchers advance university, Government, and industry investigations from initial concepts to ground testing in the Center's drop facilities before delivering them to the International Space Station (ISS). GRC also applies this payload development knowledge to balloon-borne planetary science observatories and payloads.

Strategic Goal 2 - Extend Human Presence Deeper into Space and to the Moon for Sustainable Long-Term Exploration and Utilization.

Electric propulsion and power are essential to the human exploration of deep space. GRC is NASA's lead for those areas from early phase research projects to flight systems development and transfer to industry to enable commercial production. GRC is leading formulation of the Power and Propulsion Element for the Lunar Orbital Platform - Gateway, based on its experience developing of solar electric propulsion systems. The Center continues to support operations and upgrade of the space station power system. It also is developing power technologies for planetary surface operations, including small fission power plants that can be used in space and on the ground.

GRC helps build NASA's new deep space transportation system. The Center is responsible for integrating the European Service Module, the Orion crew vehicle's primary power and propulsion component, into the spacecraft. It manages the prime contract for the Universal Stage Adapter that will be used to attach Orion to its rocket, the Space Launch System (SLS).

GRC is NASA's lead for in-situ resource utilization, coordinating all the work that will enable the use of natural resources found in space. The Center also develops and validates cryogenic fluid management technologies needed for future NASA deep space human exploration architectures. GRC applies its expertise in physical sciences and payload development to the development of astronaut exercise equipment, compact diagnostic tools, and digital simulation of physiological responses to microgravity conditions.

Strategic Goal 3 - Address National Challenges and Catalyze Economic Growth.

GRC collaborates with industry to solve aerospace problems related to the Center's competencies in air-breathing propulsion; in-space propulsion and cryogenic fluids management; power and energy storage and conversion; communications technology and development; physical sciences and biomedical technologies in space; and materials and structures for extreme environments.

The Center applies its expertise in advanced power and propulsion systems to address societal challenges related to aircraft noise, emissions, and flight safety. It ensures U.S. leadership in the development of electrified aircraft propulsion and enhances aircraft safety with technology that improves communication and helps predict and prevent propulsion and airframe icing.

GRC catalyzes economic development by engaging with and transferring technology to the private sector. The Center also supports science, technology, engineering, and mathematics (STEM) engagement activities, engaging academia to accelerate the development of space technologies.

Strategic Goal 4 - Optimize Capabilities and Operations.

GRC's space and aeronautics test facilities are National assets that provide capability to assess in-space propulsion and power systems, and simulate flight envelopes ranging from subsonic through hypersonic. GRC also conducts full-scale and end-to-end evaluations of airframes, engines, and other propulsion system components; acoustics, materials, and structures; and electric aircraft powertrains. The Center looks for public-private partnerships wherever feasible to maximize industrial benefit and minimize cost of activities.

Goddard Space Flight Center (GSFC)

Strategic Goal 1 - Expand Human Knowledge through New Scientific Discoveries.

GSFC both enables and conducts science research from space. Its measurements, modeling and theoretical investigations in the areas of Earth science, planetary and lunar science, heliophysics and astrophysics expand knowledge, National capability, and opportunities for collaboration on a variety of flight missions and field campaigns. GSFC teams work with other NASA Centers, academia, and industry to conceptualize, design, build, test, integrate, and operate space, airborne, and ground-based missions, spacecraft, and state-of-the-art instruments. The Center's renowned in-house space and Earth scientists help to focus scientific requirements for each mission and then process, analyze, and use the data to advance essential understanding of Earth, the solar system, and the universe.

Strategic Goal 2 - Extend Continuous Human Presence Deeper into Space and to the Moon for Sustainable Long-Term Exploration and Utilization.

Goddard supports NASA's goal of extending humanity's presence in space in several ways. The GSFC-managed Space and Near Earth Networks provides space communications for all human spaceflight programs as well as other Agency programs. The Center's launch range, vehicle processing, and payload processing capabilities at Wallops Flight Facility help keep the ISS supplied with experiments and life support necessities. GSFC also develops technology that improves crew safety today and enables the exploration concepts of tomorrow, such as advanced robotic and in-space assembly systems, and scientific instruments, models, and research that characterize the unknown, identify threats, and highlight opportunities for human explorers.

Strategic Goal 3 - Address National Challenges and Catalyze Economic Growth.

The innovation culture at GSFC enables commercial and economic growth on a National scale. GSFC's missions drive technological innovation that affect people every day. Worldwide weather reports are possible because of satellites developed at the Center and its search and rescue technology saves lives. GSFC detects and models space weather events to protect astronauts and satellites in orbit, and communications and power infrastructure on the ground. Further, GSFC transfers its innovations to industry for commercial applications. Such as advanced laser and X-ray systems for new communications and medical imaging systems and in-space robotics for safer mining and drilling. The Center's science-driven, component miniaturization is helping to inform the next generation of consumer and industrial systems.

GSFC directly involves universities, faculty, students, and researchers as principal partners in all phases of its work. It uses STEM experimental learning activities, internships, fellowships, and post-doctoral opportunities to translate its core missions into experiences that motivate and inspire students and educators at all levels. Thousands of students each year apply for internships and other opportunities to work at the Center.

Strategic Goal 4 - Optimize Capabilities and Operations.

GSFC manages one of the Agency's largest portfolios of cooperative and reimbursable agreements with industry, other Government agencies, and international partners. These include a longstanding agreement to

provide weather and terrestrial observing satellites to the National Oceanic and Atmospheric Association (NOAA) and the U.S. Geological Survey.

GSFC's spacecraft integration facilities, launch facilities, instrument test facilities, scientific research labs, and world-spanning communication and computer networks are integral to NASA's Mission and the Nation. The Center partners with the Commonwealth of Virginia to support commercial launches of station resupply missions from Wallops Island, Virginia. Its Independent Verification and Validation (IV&V) facility in Fairmont, West Virginia provides software assurance services to projects across NASA. The Center manages electrical, electronic, and electromechanical (EEE) parts services for the Agency.

Jet Propulsion Laboratory (JPL)

Strategic Goal 1 - Expand Human Knowledge through New Scientific Discoveries.

JPL formulates, develop, operates and exploits data from science-driven robotic space missions to answer humanity's fundamental questions. JPL develops autonomous robotic systems to image distant objects with new telescopes, conducts scientific inquiries in-situ and with remote sensing instruments, transmits the data from these robotic spacecraft back to scientists and the public on Earth via the Deep Space Network (DSN), and returns with samples.

Strategic Goal 2 - Extend Continuous Human Presence Deeper into Space and to the Moon for Sustainable Long-Term Exploration and Utilization.

JPL develops advanced exploration systems and conducts precursor missions to achieve human exploration and scientific research objectives. This includes infusing revolutionary technology designed to overcome the most vexing challenges facing human space flight. JPL meets the challenges in numerous ways with its mission designs; spacecraft entry, descent, and landing systems; deep space tracking, navigation, and communications systems; surface robotics and mobility systems; in-situ resource prospecting and utilization technologies; chemical propulsion flight system integration; advanced electric propulsion systems and related low-thrust mission design; space vehicle and habitat environmental monitoring systems; radiation tolerant, hardened avionic systems, and EEE parts; power technology and systems integration; and technology for deep space autonomous operations.

Strategic Goal 3 - Address National Challenges and Catalyze Economic Growth.

JPL addresses a broad range of topics of National interest and of direct benefit to society, consistent with its leadership role in robotic space exploration and as the only NASA Federally Funded Research Development Center (FFRDC). Examples include the application of space technology to solve challenges in medical engineering and healthcare, National defense and intelligence services, and energy production. JPL partners with academic and commercial entities to commercialize and transfer technologies it develops for NASA. JPL engages the public through open houses, live webcasts of critical mission activities, DSN visitor centers on three continents, and speaking engagements by JPL researchers. JPL's award-winning social media platforms, applications, and content are widely viewed across the globe, informing the public, encouraging diversity in our activities, and stimulating economic growth.

Strategic Goal 4 - Optimize Capabilities and Operations.

JPL supports this goal by assuring safety and mission success (SMS) for flight programs and projects, people, the environment, and critical infrastructure (such as the DSN and Advanced Multi-Mission Operations Systems). JPL develops robotic space exploration missions using tried and true, rigorous processes that identify, communicate, and manage their associated risks. The Center emphasizes continual process improvement and infusion of advanced technologies to improve efficiency. JPL also provides the Agency with mission and flight systems engineering capabilities based on the integration of science, engineering, and new technology development. Finally, JPL pursues advanced capabilities in communications, navigation, artificial intelligence, electric propulsion, instruments and sensors, avionics, and robotics.

Johnson Space Center (JSC)

Strategic Goal 1 - Expand Human Knowledge through New Scientific Discoveries.

JSC manages the ISS, which provides long-duration microgravity for continuous and interactive research. Human Research Program experiments on the space station are expanding our capabilities to protect the health and safety of astronauts, including future deep space missions on Orion. JSC curates all of NASA's extraterrestrial sample collections. The Center also applies the Agency's knowledge in orbital debris modeling and micrometeoroid and orbital debris risk analysis to spacecraft, image analysis and Earth observations.

Strategic Goal 2 - Extend Continuous Human Presence Deeper into Space and to the Moon for Sustainable Long-Term Exploration And Utilization.

JSC leads mission design and requirements development for crewed exploration missions. The ISS continues to find innovative ways to fly and test hardware that will be required for deep space exploration. This includes some key advanced environmental control and life support systems and spacesuit components, which will be tested using accelerated and streamlined processes for flight hardware development, managed by JSC. The Center also leads development of the Orion crew vehicle, whose design is flexible enough to support deep space missions as close by as the Moon and as far away as Mars. Orion is equipped with advanced technologies and backup capabilities to ensure its mission performance is safe, reliable and successful. JSC leads development for the Lunar Orbital Platform - Gateway, a crew-tended spaceport in lunar orbit.

Strategic Goal 3 - Address National Challenges and Catalyze Economic Growth.

Experiments on the space station and advanced technology work at JSC lead to applications that improve life on Earth. Remote sensing of hurricanes, advanced medical diagnostic techniques and pharmaceutical investigations are just a few of the many examples. JSC programs such as ISS, Orion, and human research, along with the Center's support of commercial crew activities, provide billions of dollars of development activity across the country. Through commercial and academic partnerships and technology transfer, JSC strengthens the high-tech industrial base and supports development of a marketplace in low Earth orbit. The Center also participates in the Agency's efforts to engage the public in our missions. It supports media from around the world, provides opportunities for public interaction with astronauts, and sponsors STEM activities with a broad and diverse community of students.

Strategic Goal 4 - Optimize Capabilities and Operations.

JSC collaborates with the Commercial Crew Program (CCP) at NASA's Kennedy Space Center (KSC) on a new development and certification process for getting U.S. astronauts to and from the ISS. The space station program and JSC's Flight Operations Directorate have succeeded in reducing operational costs and developing new capabilities, all while increasing science utilization and commercial access.

Kennedy Space Center (KSC)

Strategic Goal 1 - Expand Human Knowledge through New Scientific Discoveries.

KSC procures all classes of commercial launch services for NASA's science and robotic missions, ranging from Venture Class for the smallest and lightest CubeSat satellites to Heavy Class for the largest and most massive space telescopes. The Center also leads plant research and production in a microgravity environment NASA's Human Exploration and Operations Directorate.

Strategic Goal 2 - Extend Continuous Human Presence Deeper into Space and to the Moon for Sustainable Long-Term Exploration And Utilization.

KSC provides program and project management support for NASA's exploration mission in several ways. It leads processing, assembly, integration, and test of payload and flight science experiments bound for the ISS. KSC also supports research, development, testing, and demonstration of advanced flight systems and

transformational technologies to advance exploration and space systems. The Center designs, develops, operates and sustains flight systems, ground systems, and support infrastructure. Its Ground Systems Development and Operations Program leads launch processing for the integrated launch vehicle and spacecraft to advance human exploration. This includes vehicle and spacecraft processing, servicing, maintenance, command, control, and telemetry; launch, landing and recovery; and crew support. KSC supports habitation space systems development and operations and supports in-situ resource utilization.

Strategic Goal 3 - Address National Challenges and Catalyze Economic Growth.

KSC collaborates with partners, including other NASA Centers and external entities, to advance and share technology, promote STEM learning, and engage with the public regarding NASA's mission.

Strategic Goal 4 - Optimize Capabilities and Operations.

KSC leads partnership development strategies and operations for the Nation's pre-eminent multi-user spaceport, supporting government and commercial operations. KSC's CCP acquires and manages commercial transportation services, including development and human certification of integrated commercial crew systems and flight certification for each crew transportation mission to and from the ISS. KSC's Launch Services Program acquires and manages commercial launch services, including certification and technical insight and approval on commercial launch vehicles for NASA's science and robotic missions.

KSC enables NASA mission success and makes the space enterprises of NASA, other government agencies, and the commercial sector more capable and affordable.

KSC safely and strategically optimizes its workforce and provides innovative, cost-effective and efficient center services to support the Agency's mission. KSC continually evaluates and aligns its highly valued people and programmatic and institutional capabilities to implement rigorous and innovative safety, engineering, IT, and other services to ensure quality, timely, and reliable products.

Langley Research Center (LaRC)

Strategic Goal 1 - Expand Human Knowledge through New Scientific Discoveries.

Researchers at LaRC work to understand air quality, radiation and climate, and atmospheric composition. They also develop active remote sensing techniques to boost the quality of atmospheric data. In pursuing these goals, LaRC leaders balance advanced instrument development, field and space-borne experiments and data retrieval, analysis and archiving.

LaRC also hosts the National [DEVELOP program](#) that addresses environmental and public policy issues through collaborative research projects connecting NASA data to regional concerns around the globe. The Atmospheric Science Data Center houses the world's most comprehensive collection of atmospheric data.

Strategic Goal 2 - Extend Continuous Human Presence Deeper into Space and to the Moon for Sustainable Long-Term Exploration and Utilization.

LaRC creates concepts and tools necessary for human exploration of the solar system, particularly to ensure safe and efficient travel to low Earth orbit, the cis-lunar exploration gateway, and beyond into deep space. LaRC leads development of new high-mass entry, descent, and landing technologies; advanced radiation protection and sensor systems; advanced structures and materials for the SLS; and deep space habitation systems.

LaRC supports Orion crew vehicle's development through leadership of the Orion Launch Abort System and development of heatshield and landing systems. LaRC develops radiation transport and design codes and forges computational frameworks that will enable development of biological countermeasures for human explorers. LaRC also cultivates novel technologies for in-space manufacturing and assembly through innovative public-private partnerships.

Strategic Goal 3 - Address National Challenges and Catalyze Economic Growth.

LaRC's research helps our Nation meet fundamental challenges that arise from the rapid evolution of aviation and space exploration. The Center's work fuels economic growth in traditional commercial aviation and space technologies as well as in new and emerging markets. LaRC is a major contributor to the Agency's New Aviation Horizon initiative in experimental flight demonstrators, also known as X-planes, beginning with the Low Boom Flight Demonstrator to help enable supersonic flight over land. LaRC also supports the subsequent Ultra Efficient Subsonic Transport demonstrators for greatly improved commercial subsonic aircraft. LaRC is contributing key research, technology and development to aid the emergence of on-demand mobility, which will augment the Nation's scheduled commercial air transport infrastructure, offering air travel to anyone at any time. LaRC's focus is on addressing key technology barriers to the growth of traditional and emerging aviation markets: noise reduction, vehicle efficiency, safety and autonomy. LaRC works to remove or reduce those barriers for vehicles as well as for operations of the National airspace system.

LaRC also leads and supports activities including manufacturing initiatives in composite structures and materials. The Center promotes public-private partnerships with in-space manufacturing and assembly and supports industry partners developing commercial space transportation systems for access to low Earth orbit and beyond. LaRC ensures that NASA leverages the burgeoning autonomy technology area to benefit a variety of NASA missions.

Strategic Goal 4 - Optimize Capabilities and Operations.

In concert with our strong partnership and safety culture, LaRC attracts a highly skilled workforce and provides the infrastructure and tools needed for success. Our multi-year workforce transformation plan is strategically aligned with mission priorities and new business opportunities. LaRC's revitalization plan continues to transform our Center, aligning facilities with mission needs and expanding capabilities. Maintaining our facilities is key to the revitalization strategy. Condition based maintenance—coupled with big data analytics—allows LaRC to monitor facility health, do preventive maintenance, increase mission readiness and cut costs. The goal of revitalization is to reduce the cost of ownership for our facilities by more than \$200 million in 20 years.

Marshall Space Flight Center (MSFC)

Strategic Goal 1 - Expand Human Knowledge through New Scientific Discoveries.

MSFC develops scientific missions and instruments to expand our knowledge of Earth, the solar system, and the universe. MSFC's expertise in developing applications that use data from space-based Earth-observing instruments benefits developing countries across the globe through the SERVIR program and across the U.S. through the Short-term Prediction Research and Transitions program. MSFC scientists study the sun's dynamics to improve forecasts and use the Chandra Observatory and other instruments to study the universe. MSFC uses state-of-the-art processes to develop instruments, such as the Imaging X-ray Polarimeter Explorer, that can help us understand the origins of our universe.

MSFC is home to the Payload Operations and Integration Center, which manages all scientific research operations on the ISS around-the-clock, 365 days a year. Experiments performed on the ISS provide invaluable information to further exploration and increase our knowledge of space.

Strategic Goal 2 - Extend Continuous Human Presence Deeper into Space and to the Moon for Sustainable Long-Term Exploration and Utilization.

Throughout its history, MSFC has served as the space transportation design, development, and manufacturing leader for the Agency. Today, MSFC leverages its expertise with large-scale, complex systems to develop the propulsion, structural, life support, and engineering systems that open the space frontier.

MSFC is building the SLS, the rocket that will allow humans to travel deeper into space than ever before. MSFC has the expertise in chemical propulsion. It remains at the forefront of innovation and development of

advanced in-space (chemical, nuclear-thermal, and hybrid) propulsion systems, ascent, braking, and lander propulsion systems. The development of these systems and related technologies—including leading the development of long-term cryogenic fluid management flight systems, are essential to human exploration in deep space. MSFC also sustains current human presence in space through the environmental control and life support systems aboard the space station and is advancing those systems for human presence farther out in space.

Strategic Goal 3 - Address National Challenges and Catalyze Economic Growth.

MSFC's leadership in human space exploration benefits humankind by igniting economic growth opportunities, inspiring and educating generations, and improving life on Earth. The SLS program engages more than 1,100 contractors in 43 states. MSFC also works with industry and academia to advance manufacturing technologies (e.g. additive, welding, composites) for use in space, while establishing standards and qualifications to use these advanced techniques and parts produced for space flight.

MSFC inspires through STEM education activities and other outreach events, including hands-on learning opportunities for students such as the Human Exploration Rover Challenge and Student Launch initiative. Additionally, MSFC stimulates technological innovation through technology transfer, technology demonstration missions, and innovative Centennial Challenge competitions. These activities provide business opportunities for industry and academia while also improving life on Earth.

Strategic Goal 4 - Optimize Capabilities and Operations.

MSFC continues to identify ways to optimize its institutional performance and operations. MSFC manages sustainable facilities, promotes safety, embraces diverse viewpoints, and provides mentorship for young engineers and scientists who operate ISS experiments, test rocket engines, and study the universe. MSFC seeks partnerships through a variety of mechanisms to ensure that funds are invested wisely and the success of commercialization activities that free NASA to do what only NASA can do. MSFC provides technical propulsion support for NASA's Launch Services Program and engineering support for the CCP.

Stennis Space Center (SSC)

Strategic Goal 2 – Extend Continuous Human Presence Deeper into Space and to the Moon for Sustainable Long-Term Exploration and Utilization.

SSC continually tests SLS propulsion elements such as the RS-25 engine, core stage, and exploration upper stage. Designs and subscale testing are under way to prepare the B-2 test stand to test the exploration upper stage. SSC will continue to operate and maintain the A-1 and B-2 test stands and the Cryogenic, High Pressure Industrial Water, and High Pressure Gas facilities which support testing of the SLS propulsion system elements. In addition, the Center will direct efforts toward meeting National needs for propulsion testing.

Strategic Goal 3 - Address National Challenges and Catalyze Economic Growth.

SSC is an economic driver for the Nation comprised of a diverse community of government, commercial and academic interests. The Center provides world-class propulsion test capabilities to support NASA as well as Department of Defense and commercial customers. SSC is focused on partnering with Government agencies as well as existing and emerging commercial companies to test a variety of engines and components, thus contributing to economic growth. The Center will direct efforts toward leveraging existing technologies to streamline operations and develop autonomous technologies to operate test facilities with fewer technical personnel. Similarly, SSC will continue to engage industry through dual use partnerships and maintain an active technology transfer program with both commercial and academic partners. Stakeholder engagement will remain a key activity for SSC with efforts focused on communicating Agency and Center priorities and successes.

Strategic Goal 4 - Optimize Capabilities and Operations.

SSC senior leadership actively supports the Agency's mission support architecture initiative to evaluate and realign mission support functions while maintaining mission focus, improving efficiency, and valuing the workforce. In 2016, SSC implemented the Synergy-Achieving Consolidated Operations and Maintenance contract, optimizing capabilities and operations of SSC and MSFC's Michoud Assembly Facility (MAF). Results include streamlined management functions, reduced redundancies inherent in multiple support contractors, and increased collaboration between SSC, MSFC and MAF. Building upon these successes, SSC is developing a strategic sourcing contract, the Multiple Award Contract for Construction. This award contract will be a regional contract between SSC, MSFC, MAF, JSC, and KSC.

APPENDICES

APPENDIX A: DEVELOPING AND IMPLEMENTING NASA'S STRATEGY

NASA's Vision and Mission reflect our continual pursuit of the long-term goals originally established in the National Aeronautics and Space Act of 1958, outlined in the latest National Space Policy, and emphasized through NASA authorization acts, statements from the National Space Council, as well as National space and aeronautics policies throughout successive Administrations. The main theme of NASA's strategy remains exploration and research in space and aeronautics, together with international and domestic partners, for the benefit of all humankind. Our exploration and research efforts continually foster new discoveries that expand human knowledge, while providing significant benefits to the U.S. economy.

Our strategic goals and objectives align with our Vision and Mission, reflecting both National policies and legislation, as well as the strategic direction set by the NASA Administrator. Consultation with both external and internal stakeholders, and participation from NASA's Centers and mission directorates is essential.

The NASA Administrator utilizes several formal internal mechanisms to ensure that Agency efforts align with our strategic goals and objectives. These include the Planning, Programming, Budgeting and Execution (PPBE) process, where long-term strategic planning provides the basis for the programmatic and institutional priorities of the Agency, as well as early identification of potential Agency challenges and risks that could be potential barriers to success. In addition, the NASA Strategic Management Council (SMC), a forum of senior leaders from across the Agency, helps formulate strategy related to enhancing innovation, right-sizing NASA's infrastructure, evaluating partnerships and workforce needs, and continuous prioritizing of the Agency's portfolio of activities. The Associate Administrator for Strategy & Plans develops Agency-level strategy in consultation with external stakeholders and works with senior leadership to implement it across the Agency, providing strategic alignment of mission areas.

NASA holds its leadership fully accountable for meeting near-term performance standards and metrics as well as progress toward long-term objectives. Program authorities and the Agency governance councils hold regular internal reviews to monitor and evaluate performance and use the results to support internal management processes and decision making. The Chief Operating Officer (COO) is responsible for reviewing progress toward Agency program and project plans, and addresses cross-cutting concerns that may impact mission performance against approved plans. Additionally, NASA's COO and Performance Improvement Officer review progress toward strategic objectives annually by assessing the impact of strategies, implementation of key activities (including multi-year performance goals, annual performance indicators, agency priority goals, and cross-agency priority goals). Decisions are informed by leveraging evidence, evaluation, studies, and independent analysis to identify challenges, risks, and opportunities to ensure mission success.

External shifts in policy, budget realities, the needs of external communities, partnerships, and industry, as well as internal capabilities, constraints, and challenges, are all key factors in NASA's ability to deliver upon the strategic objectives outlined in this document. To ensure success in a dynamic environment, NASA's long-term strategic planning process is ongoing and iterative, allowing for flexibility in the event that external guidance or circumstances necessitate revised strategies. NASA strives to be proactive in its strategy, reflecting the Agency's commitment to continued leadership in space exploration, development of new technologies, innovation, and scientific discovery. Above all, NASA strives to maintain the public's trust through responsible stewardship of the taxpayers' investment in the Agency.

APPENDIX B: FY 2018-19 AGENCY PRIORITY GOALS

This appendix incorporates NASA's FY 2018-19 agency priority goals (APGs) in the *2018 Strategic Plan*. An APG supports improvements in near-term outcomes and advances progress toward longer-term, outcome-focused strategic goals and objectives in the strategic plan. It is a near-term result or achievement that leadership wants to accomplish that relies predominantly on agency execution to be accomplished. Agency priority goals reflect the top implementation-focused, performance priorities of Agency leadership and the Administration, and therefore do not reflect the full scope of our Mission. More information on these APGs is available on www.performance.gov.

Goal statements for the APGs are as follows:

James Webb Space Telescope (Webb)

Strategic Objective 1.1

Revolutionize humankind's understanding of the Cosmos and humanity's place in it. The James Webb Space Telescope (Webb) will study every phase in the history of our universe, ranging from the first luminous glows after the Big Bang, to the formation of other stellar systems capable of supporting life on planets like Earth, to the evolution of our own solar system. By September 30, 2019, NASA will initiate on-orbit commissioning of Webb after launch.

Mars 2020

Strategic Objective 1.1

Seeking signs of life on Mars: Explore a habitable environment, search for potential biosignatures of past life, collect and document a cache of scientifically compelling samples for eventual return to Earth, and contribute to future human exploration of Mars. By August 5, 2020, NASA will launch the Mars 2020 rover. To enable this launch date, NASA will deliver the instrument payload for spacecraft integration by September 30, 2019.

International Space Station (ISS)

Strategic Objective 2.2

Use the ISS as a testbed to demonstrate the critical systems necessary for long-duration missions. Between October 1, 2017, and September 30, 2019, NASA will initiate at least eight in-space demonstrations of technology critical to enable human exploration in deep space.

Exploration

Strategic Objective 2.2

Achieve critical milestones in the development of new systems for the human exploration of deep space. By September 30, 2019, NASA will conduct the Ascent Abort-2 test of the Orion Launch Abort System, perform the green run hot-fire test of the Space Launch System's Core Stage at the Stennis Space Center, and roll the Mobile Launcher to the Vehicle Assembly Building to support the start of Exploration Mission-1 stacking operations.

Commercial Crew Program (CCP)

Strategic Objective 4.2

Facilitate the development of and certify U.S. industry-based crew transportation systems while maintaining competition, returning International Space Station crew transportation to the United States. By September 30, 2019, the Commercial Crew Program, along with its industry partners, will complete at least one Certification Review, following un-crewed and crewed test flights to the ISS.

APPENDIX C: CROSS-AGENCY PRIORITY (CAP) GOALS

The cross-agency priority (CAP) goals focus on major issues that require active collaboration between multiple Federal agencies and are intended to accelerate progress on a limited number of Administration priorities. The Government Performance and Results Modernization Act of 2010 requires agencies to address the CAP goals in their strategic plans, Annual Performance Plans (APPs), and Annual Performance Reports. Please refer to <http://www.performance.gov> for more information on the FY 2018-21 CAP goals, including progress updates and NASA's contributions to the goals, where applicable.

To ensure effective leadership and accountability across the Federal Government, each CAP goal typically has a named senior leader within the Executive Office of the President and another within one or more of the key delivery agencies. NASA is not a goal leader for any of the FY 2018-21 CAP goals, but does support select goals. NASA will provide additional information on its specific contributions to the CAP goals, where appropriate, in its *FY 2020 Volume of Integrated Performance*, scheduled for release in February 2019.

APPENDIX D: PERFORMANCE GOALS

For NASA's performance goals and annual performance indicators, please see the current version of the APP within the Volume of Integrated Performance. The 2019 Volume of Integrated Performance, aligned with the 2018 Strategic Plan, will be published in accordance with OMB guidelines.

APPENDIX E: MANAGEMENT OBJECTIVES

Strategic objectives reflect the outcome or management impact the agency is trying to achieve and generally include the agency's role. Each objective is tracked through a suite of mid-term performance goals as well as accompanying annual performance indicators that are established separately in the APP. While not required, OMB encourages agencies to include management-focused objectives within their strategy performance framework. Management-focused objectives communicate improvement priorities for management functions such as strategic management of human capital, administration and control of information technology, efforts contributing to long-term sustainability, or stewardship of financial resources. NASA has captured these activities within Strategic Goal 4, a hybrid goal that highlights the emphasis the Agency places upon optimizing capabilities and operations for the future. Specifically, strategic objectives 4.1, 4.3, 4.4, 4.5, and 4.6 may be considered "management-focused" objectives.

APPENDIX F: REGULATORY REFORM

Under Executive Order (EO) 13777, titled "Enforcing the Regulatory Reform Agenda," NASA is required to identify a Regulatory Reform Officer and establish a Regulatory Reform Taskforce to evaluate existing regulations and make recommendations to the Administrator regarding their repeal, replacement, or modification, consistent with applicable law. To report the progress of NASA efforts toward meeting the requirements of EO 13777 and 13771, NASA has issued 0 of regulatory actions, 0 of deregulatory actions, and imposed 0 total incremental costs associated with regulatory actions in FY 2017. For FY 2018, NASA has set a goal of imposing 0 total incremental costs associated with regulatory actions in FY 2018. The costs reported are annualized at a 7 percent discount rate and are expressed in 2016 year dollars.

APPENDIX G: ACRONYM LIST

Acronym	Definition
AFRC	Armstrong Flight Research Center, Edwards, CA
APP	Annual Performance Plan
ARC	Ames Research Center, Moffett Field, CA
ARMD	Aeronautics Research Mission Directorate
CASIS	Center for the Advancement of Science in Space
CCP	Commercial Crew Program
CoF	Construction of Facilities
DHS	Department of Homeland Security
DoD	Department of Defense
DoE	Department of Energy
DSN	Deep Space Network
EEE	Electrical, Electronic, and Electromechanical
FFRDC	Federally Funded Research Development Center
GRC	Glenn Research Center, Cleveland, OH
GSFC	Goddard Space Flight Center, Greenbelt, MD
HEOMD	Human Exploration and Operations Mission Directorate
HRP	Human Research Program
ISS	International Space Station
IV&V	Independent Verification and Validation
JPL	Jet Propulsion Laboratory, La Cañada Flintridge, CA
JSC	Johnson Space Center, Houston, TX
KSC	Kennedy Space Center
LaRC	Langley Research Center, Hampton, VA
LEED	Leadership in Energy & Environmental Design

Acronym	Definition
LEO	Low Earth Orbit
LSP	Launch Services Program
MAF	Michoud Assembly Facility
MSD	Mission Support Directorate
MSFC	Marshall Space Flight Center, Huntsville, AL
NOAA	National Oceanic and Atmospheric Administration
OCE	Office of the Chief Engineer
OCHMO	Office of the Chief Health and Medical Officer
OCIO	Office of the Chief Information Officer
OCOM	Office of Communications
OSMA	Office of Safety and Mission Assurance
R&D	Research and Development
RPT	Rocket Propulsion Test
SCaN	Space Communications and Navigation
SCAP	Strategic Capabilities Assets Program
SSC	Stennis Space Center, Stennis Space Center, MS
SETMO	Space Environments Testing Management Office
SLS	Space Launch System
SMD	Science Mission Directorate
SMS	Safety and Mission Success
SOFIA	Stratospheric Observatory for Infrared Astronomy
STEM	Science, Technology, Engineering, and Mathematics
STMD	Space Technology Mission Directorate
Webb	James Webb Space Telescope



National Aeronautics and Space Administration

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